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JANUARY 1997 £2.35

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Kanda Systems/ ETI Design Competition see page 9

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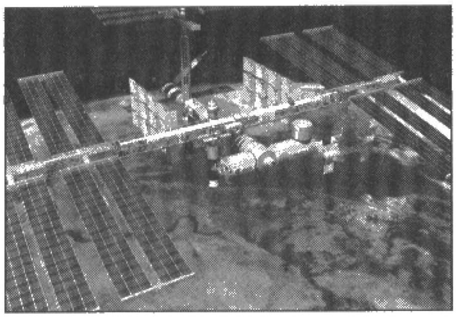
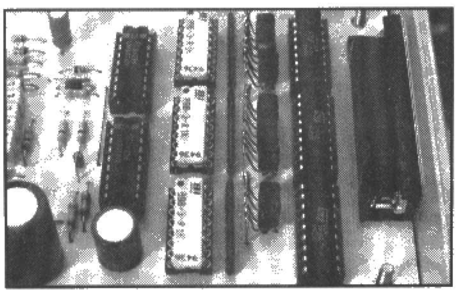
& Features Projects



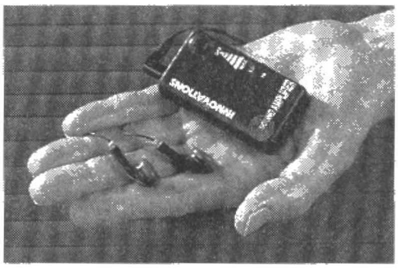


Regulars

ETI ELECTRONICS TODAY INTERNATIONAL News...

Innovations for Christmas

The August-December 1996 Innovations Report is a mine of practical gift ideas at this time of year, not a few of which will appeal to those who can't resist a handy portable gadget every now and then. The Innovations Personal Amplifier (£14.95) is small enough at 2x7x4cm for a shirt pocket but contains a 'powerful condenser microphone capable of picking up the smallest sounds either indoors or out' - a help to anyone who has trouble picking out conversations, following the TV or hearing films or plays from their usual seat. The unit has a Hi-Lo frequency response switch and comes with two button earphones and a clip. The Cell Patch cellphone booster (£11.95) boosts the reception of cellphones to help get around signal dropouts or interference, without wires or batteries. Measuring 9.5 x 8.8 cm, this thin layer antenna can adhere to your car windscreen sun-visor near to the handset, or can be carried in a packet. 'Works with all types of portable cellular phone'. The Innovations MemoPad 570 (£29.95) acts as a portable, vocal envelope-back - with dimensions of 8 x 5 x 2 cm, fitting easily in one hand, the MemoPad can record up to 70 seconds of messages on five separately-selectable channels of up to 14 seconds each. The channels can be erased separately. The device could be a family or group memo pad if each person is allocated one channel. Messages are retained if the 4 X G13 button cells run out - handy if no-one has been voted "the one" to check the batteries.



The increasingly well-known Trafficmate motorway traffic jam warning system (£54.95) is also on Innovations' books. The Trafficmate receives signals from the National Traffic Data Centre's system of motorway monitor sensors. If average speeds drop to below 30 mph, the sensors send a signal to the Data Centre, which relay the warning to your Trafficmate as a voice message. The device is licensed by an annual "information key" (free here for the first year on purchase) and uses 4 X A4 batteries. A plug-in radio-controlled Remote Control Unit (£39.95 for a single switch, £89.00 for a three-switch unit) allows you to switch domestic appliances within 25 metres remotely via a small handset, and a receiver module that plugs into the mains wall-socket. The appliance you want to switch then plugs into the receive unit, and presto ... a 12 volt alkaline battery is supplied.

The December catalogue also features a car headlamp warning add-on (£4.95) for forgetful parkers, a wire/pipe tracer (£18.00), a multi-function test-centre for household circuits, switches, batteries, bulbs and so on (£29.95) and some longlife light bulbs for those who trust themselves with fragile glass objects, and quite a few other dinky electrical and electronic gadgets - including a flea-zapper for cats! (£39.95).

Innovations is taking Christmas orders up to 16th December - for a catalogue or information ring 01793 410011 (24 hours), or visit their shop at 19 Paradise Road, Richmond, Surrey (0181 948 3792 - check availability if travelling from a distance).

New free catalogue from connector manufacturer

Now available free from Rendar Ltd. is a new 48-page catalogue giving their extended list of audio, power and communications connections. This year's new introductions reflect Rendar's investment in new product development and automated production. Rendar is proud of the durability, reliability and cost-efficiency of its UK-manufactured product lines.

Among the new products are Quadbloc, giving multiple IEC 320 outlets with a high degree of flexibility for connection of accessories such as filter capacitors, inlets, switches, fuses or neon indicators. The DB2000 is a fully integratred electrical service system that allows easily configured "plug and go" installation of mains services in office or workplace, suitable for all international plug specifications, and also supporting data communications.

Also new this year are UK-USA voltage changes that enable 110V-rated equipment to be used on the 240V mains, or vice versa.

For further information, contact Duncan Palmer, Rendar Ltd., Durban Road, South

ETI ELECTRONICS TODAY INTERNATIONAL News...

Young Electronic Designer Award

The Young Electronic Designer Awards are open to all full time students between the ages of 12 and 25. The aim of the Award is to encourage people studying electronics to design and produce a practical device or system that satisfies an everyday need. Project can be an integral part of students' course work.

The Awards are co-sponsored by Mercury Telecommunications and Texas Instruments (TI) in association with the Institution of Electrical Engineers (IEE) particularly to encourage the designers of the future to look at electronics in a practical and production-oriented way. Electronics courses have often been criticised for producing graduates with very little appreciation of the needs business or customers in the real world, even at the most basic production levels.

The YEDA judging criteria closely match those used by commercial organisations to assess new technical developments: originality, technical competence and reliability, construction and presentation, everyday usefulness and commercial feasibility. This means that the designer must understand something about the people who will use the finished article, ease and safety of use, reliability and demand.

Prizes include cash awards of up to £2,500 to be shared by the winning students and their schools or universities, computer and communications equipment, certificates and trophies.

1996's winners included a microprocessor-based sunbathing warning device, an accessible multimedia education system, a head-up stopping display for motor cards and an audio pre-amplifier, among others.

Completed entry forms must be in by 31st January 1997, regional judging takes place between 20th and 28th February 1997, and the finals are at the Science Museum, London, on 25 and 26th March 1997, culminating in a gala presentation dinner on 26th.

Entry forms and further details are available from The YEDA Trust, 60 Lower St., Pulborough, W. Sussex RH20 2BW. Tel 01798 874767 Fax 01798 873550.

Keen electronics hobbyists at school or university but not studying in the electronics stream may not be aware of the competition. If you are one, it may be worth getting an entry form to find out if you are eligible.

Shorts

South Essex Amateur Radio Society Radio Rally takes place at the Paddocks (on the A130), Long Road, Canvey Island, Essex from 10.30. Admission £1.00. Further details from David G4UVJ tel 01268 697978 ... Microsoft, the software giant that produces many of the world's leading PC packages, is considering putting a software licence lock into Microsoft Office 97, the forthcoming version of its best-selling Microsoft Office suite. Microsoft's researchers have calculated that software piracy is still running at around 38%. This implies that if software piracy could be stopped altogether, the turnover of Microsoft and other major software producers would increase by nearly 40%. Software producers have been striving for a long time to find a reliable way of limiting the reinstallability of major software, without deterring legitimate users concerned about being unable to reinstall software after hardware crashes, disk damage and other secondary causes of software malfunction, as well as reinstalling after hardware upgrades which, in today's climate of escalating memory requirements, are often undertaken annually or more often ...

MODSMODSMODSMODSMO

In the ETI MicroAmp, part 2, November 1996, figure 7, R114, 115 and 116 should be 3k3. In figure 8, the capacitors on pin 5/8 of 1C10 and 5/8 of IC13 are C43 and C49 respectively, and should both be 22p. The Parts List (which appeared in October in Part 1) is correct.

In the Powerline Signal Controller, part 1, October 1996: in figure 2, Q1, Q2 and Q3 should all be 2N3903. Otherwise, the BC548 (Q3) should be where Q1 (the 2N3903) is shown, and vice-versa. In figure 3, the capacitor between T1 and R7 is C3. The connection of C1 to C7 is shown differently in figures 2 and 3, but either configuration will work.

In Part 2, November 1996, Q1 should be a PNP BC558. In figure 5, C1 should be 470n:C3 is back to front (figure 6 is correct). D2 should be a 15V device, not 3.9V as shown. In figure 6, C6 is next to C3, with C5 below it and T1 alongside.

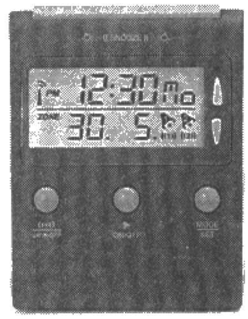
ETI ELECTRONICS TODAY INTERNATIONAL News...

Super-accurate alarm clock is good value

Do you know somebody - a family member maybe? - who could make good use of a high-accuracy electronic alarm clock for a non-alarming price? Oregon Scientific's Model RM 838 (available from branches of high street jewellers H. Samuel, and Argos) not only promises to wake you gently and gradually with a 2-minute crescendo alarm, but is accurate to one-millionth of a second per year thanks to the signal broadcast from the official British standard frequency and time signal transmitter - "MSF" - maintained by the National Physical Laboratory in Middlesex.

The signal gives the time in hours, minutes and seconds, date and day of the week (in four languages), and shows the signal strength upon last reception if you are away from home. The clock also adjusts to UK changes from British Summer Time to Winter Time without knobs and buttons.

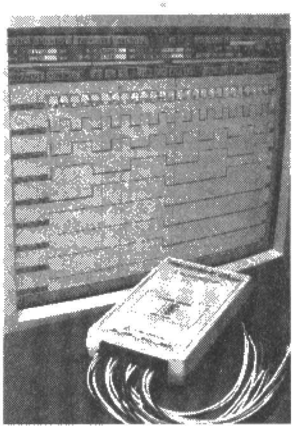
The RM 838 is priced at £19.99 and also features Oregon's own "HiGlo" backlighting that lights up when the alarm sounds or when the 8-minute snooze function is set. The MSF 60kHz time signal, based on a Caesium atomic clock, is received by each radio controlled clock from a BT International transmitter in Rugby, UK, with a range of 1500 km (1000 miles).



For more information see your local dealer or contact Oregon Scientific Tel 01628 836 688 Fax 01628 826 922.

WIN an Advanced Logic Analyser

NEW TO THE UK MARKET!



FEATURES:

- Genuine 50MHz capture, NOT glitch capture
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- User labels capability
- 8K of trace memory (upgradeable to 32K)
- 7 Trigger levels and conditions
- Advanced Clock facilities

This first rate unit can be yours if you win our Design Award. This instrument will let you know exactly what your code is doing and will all the features you would expect from a unit designed for leading edge R&D work, and yet it is extremely easy to use.

This award is co-sponsored by ETI and Kanda Systems and offers you the chance to present your design skills and win a valuable prize. In addition you will have the opportunity to turn your idea into a saleable product and get help with manufacturing and marketing. Even if you are not the prizewinner, you will have the possibility of working with us to develop your idea if your design has commercial potential.

Competition Rules: 1. Open to anyone, regardless of age, gender, occupation etc., except employees of Nexus or Kanda Systems and their immediate relatives. 2. Entries welcome from groups, eg student classes. 3. More than one entry can be accepted from any person or group. 4. The competition will be judged jointly by Helen Armstrong, ETI editor, and Kanda Systems' senior design engineer, Kevin Kirk. 5. The design must be based around a microcontroller. 6. The judges' decision is final and no correspondence will be entered into. 7. Copyright of the design remains the property of the competitor. 8. Acceptance of the award gives the competition sponsors the right to publicise the award. 9. Competitors who do not win may, if their designs are of sufficient quality, be offered the opportunity to develop their design in association with Kanda, and ETI may wish to feature their designs. 10. The closing date for entries is 30th March 1997, and NO entries can be accepted after this date.

The Winner will be notified by post and the presentation of the prize will be published in ETI. The judges will make their own decision, but the following pointers may help: the design must work. Economy of design (efficiency) will be considered. Imagination and originality are important.

Electronics Today International and Kanda Systems present

The ETI-Kanda Design Award

You've always wanted a state of the art Logic Analyser and now is your chance to win one. All you have to do is to design a circuit that incorporates a microcontroller (PIC, 8032, etc.) and fulfils a practical application. And if your design is deemed to be commercially viable Kanda will work with you to turn it into a finished product to be sold through the Kanda Catalogue

TO ENTER, simply send a description of your design, a full circuit diagram and a clear explanation of the application and function of the circuit plus a parts ist directly to the address below. Extra information such as test results, suggested PCB layout etc. may help us to judge the design. Don't forget to include your name, address and telephone number.

***Please note** that entries cannot be returned. Kanda and ETI do not accept responsibility for any materials received. We recommend that entrants either keep clear copies of all materials sent, or send clear copies and retain the original drawings. Please do NOT send hardware at this stage.*

ETI ELECTRONICS TODAY INTERNATIONAL

ETI/Kanda Competition
Electronics Today International
Nexus House
Boundary Way
Hemel Hempstead
HP2 7ST UK

Waiting for the Space Station

An international scientific community is collaborating to create the International Space Station. Douglas Clarkeson looks at the advances that can come from space station research.

A study of the arguments for and against the massive level of expenditure on the Space Station is a study of all shades of scientific and political opinion. In the academic camp there are those who consider it invaluable to fundamental new research, while others believe that its scientific credentials are fundamentally flawed.

Amidst this wide spectrum of attitudes, the building of the Space Station in various countries around the world gathers pace. Unless there is a spectacular falling out of partners and the budget collapses, it will become a reality. To tap into the diverse strands of thought emanating from the groups engaged in its implementation is to encounter a wholly new world of outlook.

Why and wherefore

The Space Station is perceived as a significant technological challenge that has the potential to push forward technology to give the principal participants (the USA and Russia) a competitive edge for new products in medicine, engineering, communications and materials science.

It is a sad reflection that for over 50 years the world's great powers have used their very best scientific resources to develop weapons of mass destruction. The Space Station is seen as a symbol of the transformation of the adversarial aspect of technology to one of peace and co-operation. There is also the argument that to support the Space Science in Russia after the collapse of the Soviet Union will help to lessen the risk of leakage of defence technology to certain undesirable nations. There is also the argument that in the USA the project could provide continuing employment for defence workers.

The Space Station is seen as offering unique research facilities to study all manner of scientific and medical phenomena in weightless conditions of space. Previous experiments undertaken by the USA in micro-gravity have largely been undertaken by NASA using shuttle flights of limited duration. The European Space Agency EUREKA mission was flown for a period of some nine months in space and undertook a series of longer duration crystal growing experiments. While much of this work was highly interesting, opinion is divided over the relative value of continuing this line of development.

The price tag

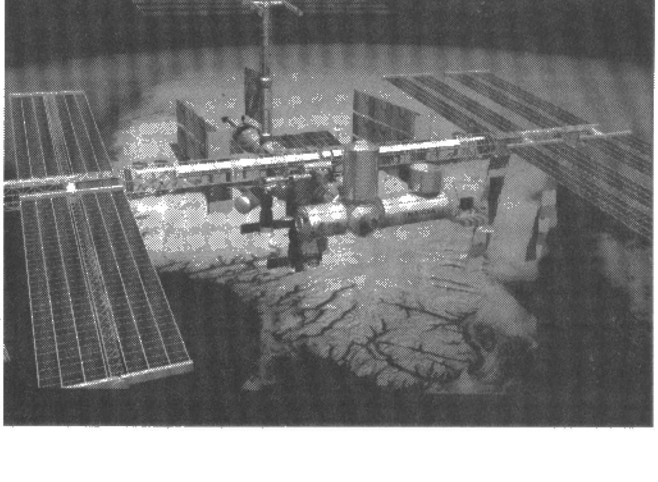
The Space Station will basically cost the USA around $17.4 billion to construct with international partners contributing an additional $9 billion. It is estimated, also, that the extensive set of 44 launches will add another $19.6 billion by the year 2002. By 2012, it is estimated that the Space Station could have cost in total $100 billion. The expense of such a venture is not so much in building it and assembling it in space, but in servicing the on-board crew.

The vast cost of the Space Station, however, gives a useful indication of the cost of any future manned flights to Mars using existing technology. The process of launching vehicle hardware, supplies, fuel, life support systems and personnel even into low earth orbit is currently exceedingly expensive. Without explicitly declaring the Mars connection, there is no doubt that in the longer term, perhaps around 2020, the life support technology that would have been refined for the Space Station would be exactly what is required for long manned space flight. The continuing refinement of unmanned space exploration vehicles, however, makes this lower cost form of research more attractive.

History: the Western view

In many ways the Space Station follows the pattern of scientific and political developments of recent times. This analysis also examines aspects of space technology from a Western perspective - which is one that not always provides a clear perspective on previous achievements of the Soviet Bloc.

After the triumph of the Apollo moon landing of 1969, the next stage was clearly seen as 'the Space Base', a 100 person permanent space station. Following a review of the costs even of resupplying such a station, NASA moved its priority to constructing the Space Shuttle - a craft that would be essential for the construction and re-supply of any future form of such



project. Skylab, launched in 1973, supported limited missions of 28, 56 and 84 days in space but it was not intended to form the nucleus of a permanent observing post in space.

Up until 1979 there was discussion between the USA and the USSR in relation to joint work using shuttle re-supply missions and manned Salyut stations in orbit though with the collapse of relations in 1979 this initiative was brought to a halt. The first successful Shuttle launch of 1981 again focused interest on what could be undertaken as the next step in the exploration of space. At the height of the Cold War in 1984 President Reagan announced that a key goal for the future would be the building of space station with help from strategic allies.

Mature designs were beginning to appear during 1986 as Space Station Development Phase B. The Challenger accident, however, forced a revision in scale to reflect the increased cost of Shuttle re-supply and in 1988 the then named Space Station Freedom was scaled down somewhat to reflect cost reductions forced by Congress.

The collapse of the Soviet Union and the resulting improvement in US/Russia relations led in turn to agreement to use the Russian Soyuz vehicles as a means of supplying the Space Station. A major redesign of Freedom was, however, forced by President Clinton in 1993 and the resulting option 'Alpha' became known as the International Space Station after the incorporation of many components of hardware which had been planned to be used in future of the Russian Mir Space Station. This is essentially where we are now - actually building the International Space Station.

It is appropriate to reflect, that the principal contractor - Boeing, stands to gain significant technological advantage in the work involved in the USA component of Space Station and this could be a factor in the maintaining technological superiority in related aerospace activity in the military and in the civilian sectors.

The difference between the approach of the East and that of the West is that in the East there is greater adherence to long term planning and goals, while in the West, the direction in technology can be utterly confused by a range of non-technical factors (such as winning elections) which cause delays and a general waste of resources. Does this indicate that the political system of the West is fundamentally flawed in how its harnesses resources in general?

Early Soviet space stations

The initial impetus for Soviet space stations was military and with key development activity around the time of the American moon landing. There was then a shift in emphasis to building civilian/scientific stations and several of the military 'Almaz' stations were redeployed as 'Salyut' stations. Several of the early flights were not successful and the crew of Soyuz 11 to Salut 1 were lost as their return vehicle lost pressurisation. Salyut missions 3,4 and 5 were however successfully completed and gradually the missions developed and supported a total of five crews. In the second generation of such stations, Salut 6 supported sixteen crews and Salyut 7 ten crews including six long duration crews. From this point onwards, future planning was for a more flexible and

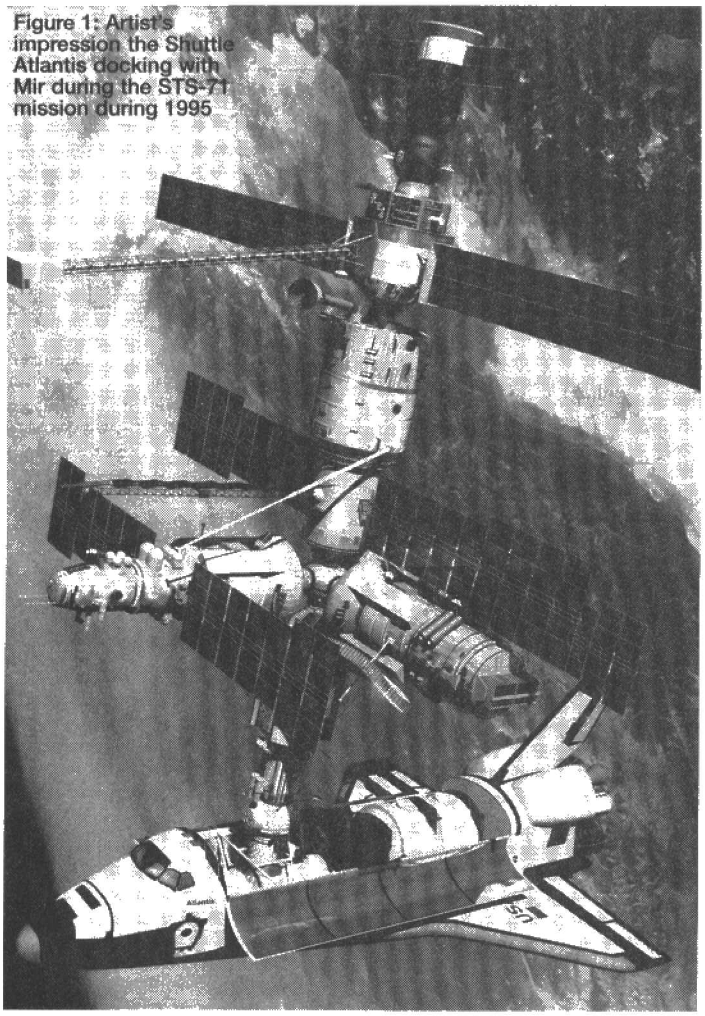
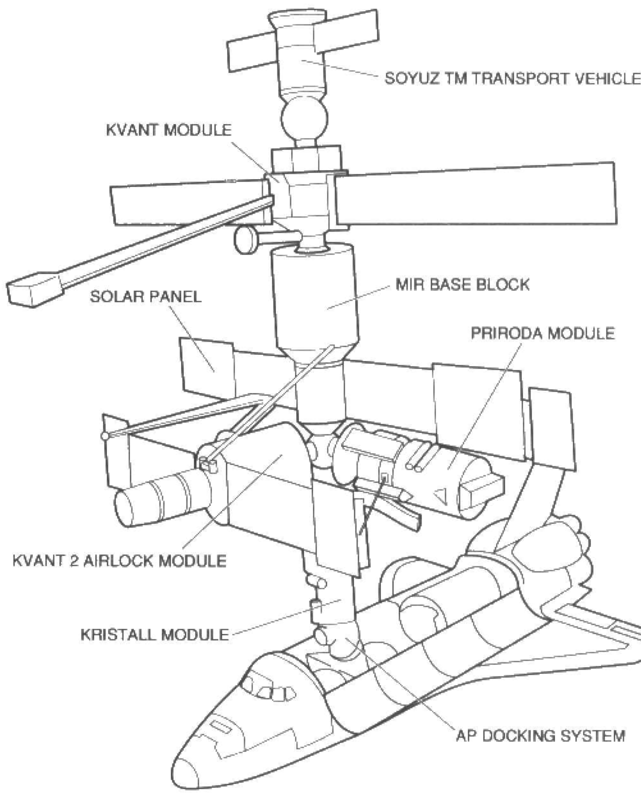


Figure 1: Artist's impression the Shuttle Atlantis docking with Mir during the STS-71 mission during 1995

Figure 2: a diagram of the various modules of the Mir station at this stage



permanent station in space - the Mir Space Station. By comparison, the US Skylab mission was a single unit that only supported three crews.

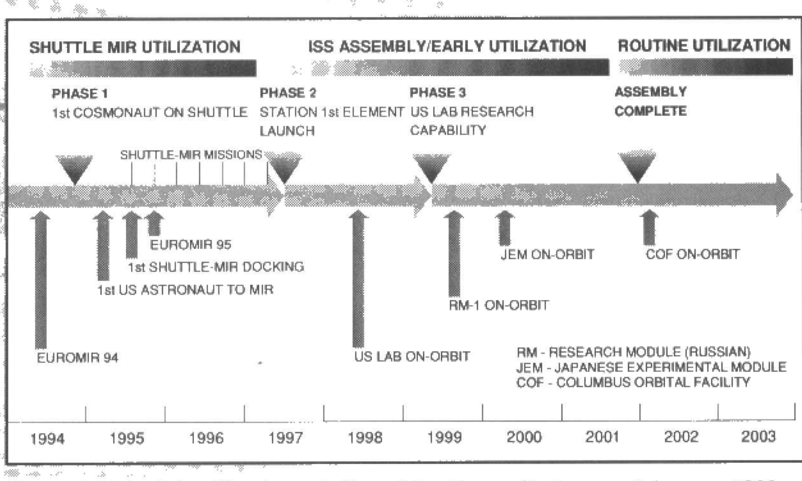


Figure 3: Schedule of Implementation of the Space Station as at January 1996

All about Mir

Seen in perspective, the Russian Mir space station was one of the high points of Soviet space achievement. It represents the third generation of space stations of the former Soviet Union and has been operational since 1986. Russian cosmonauts have lived on board Mir continuously for the past nine years and have consequently added gained considerable experience in such technology. Around 16 long duration crews have worked on Mir so far.

The total mass of Mir is currently around 100 tonnes with additions carried aloft by the Shuttle Atlantis in 1995 and 1996. In many ways the Space Station is critically dependent on the function of Mir to evaluate systems developed for the final Space Station system. The high level of reliability required for a manned station is best verified in the actual environment where such systems will be used.

The initial core module of Mir weighing 20.4 tons was launched in February 1986. This module provided basic living quarters and scientific research facilities. The Kvant module of 11 tons was added in February 1987 and provided telescopes and equipment for attitude control and life support. This was followed by Kvant 2 in 1989 weighing 19.6 tons and Kristall in 1990 weighing 19.6 tons. Up to this point the hardware on Mir was exclusively of Russian/Soviet origin. With the onset of co-operation in space, the Spektr module, a docking module and the Priroda module have been added with US help.

Module	Year	Mass	Agent	Payload
Core Mir	1986	20.4	USSR	Living quarters/ research
Kvant	1987	11.0	USSR	Life support/ telescopes
Kvant 2	1989	19.6	USSR	EVA airlock/solar arrays, life support
Kristall	1990	19.6	USSR	Docking ports, solar arrays, research equipment
Spektr	1995		RUS/ USA	Solar arrays, research equipment
Docking Module	1995		RUS/ USA	Shuttle/Mir docking system
Priroda	1995		RUS/ USA	Microgravity research, telescopes

Table 1: historical development of the Mir space station

Dr. Valeri Polyakov currently holds the world record for endurance in space. His stay of 438 days aboard Mir was achieved between January 1994 and March 1995. American astronaut and biochemist Shannon Lucid spent 188 days in space on board Mir following postponements of the Atlantis flight which eventually took off during September 1996.

Figure 1 shows an artist's impression the Shuttle Atlantis docking with Mir during the STS-71 mission during July 1995. Figure 2 indicates diagrammatically the various modules of the Mir station at this stage.

The plan ahead

While the plans for the Space Station have undergone many changes for political, monetary and scientific reasons, the core plan seeks to derive the maximum benefit from the available resources. Figure 3 summarises the plan for the Space Station as at January 1996. The first phase which began during 1994 relates to the co-operative Shuttle-Mir missions to use the Mir station as a test bed for components that would be implemented during Phase 2 and Phase 3. There will also be afforded an opportunity for the wider space community of Canada, Japan, Russia, Europe and the USA to use Mir for selected scientific research.

This will, for example, allow two Russian research modules to be used by the expanding international team. During this phase the Shuttle will provide up to ten crew exchange and logistic supply missions and provide to the USA the equivalent of two years cumulative stay on Mir. In the European perspective, ESA astronaut missions of one month and six months and with 600 kg of research hardware will also be supported.

Table 2 summarises the set of assembly flights planned and emphasises the close degree of integration of the US and Russian Space Agencies.

Flight	Vehicle	Mission Function
1A	Russian Proton	FGB tug: attitude control; docking capability
2A	US Orbiter	US Node #1: pressurised element; two lab racks
1R	Russian Proton	Russia Service Module with docking for resupply vehicle
2R	Russian Soyuz	Deployment of assured crew Return vehicle
3R	Russian Zenit	Universal Docking Module
3A	US Orbiter	First truss component; communications equipment
4R	Russian Soyuz	Russian docking compartment with airlock for EVA
4A	US Orbiter	US solar array components; communications
5R	Russian Zenit	Russian power control, attitude control, radiator
5A	US Orbiter	US pressurised laboratory
6A	US Orbiter	Experiment racks, communication equipment
6R	Russian Zenit	Additions to Russian power systems

Table 2: Summary of sequence and details of key assembly flights for the International Space Station - seven Russian and five US.

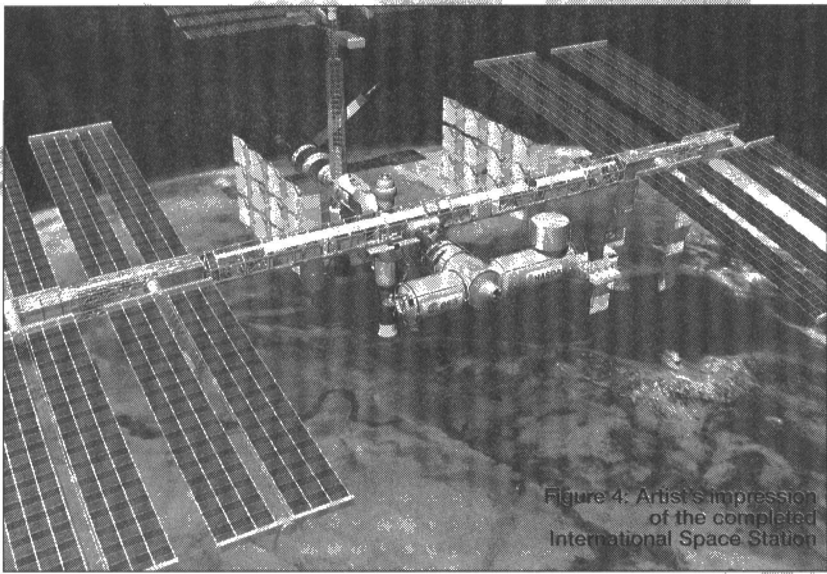
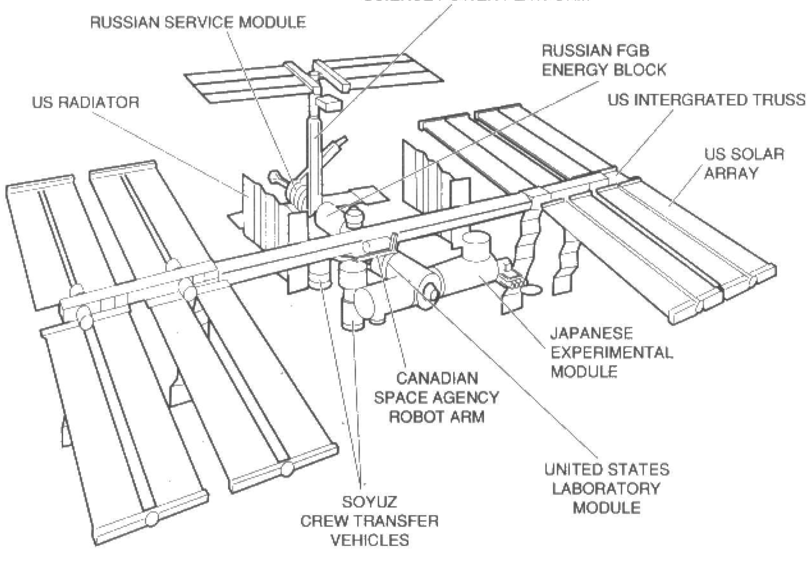


Figure 4: Artist's impression of the completed International Space Station

Figure 5: Key to main components of the completed Space Station shown in figure 4



Name	Number of stages	Low Earth Orbit payload	First developed	No. of assembly flights
Soyuz	2	7 tonnes	1963	2
Zenit	2	14 tonnes	1985	3
Proton	3-4	21 tonnes	1965	2

Table 3: Summary of Russian rockets used in the assembly of the Space Station.

As at January, 1996, however, the co-operating countries within Europe are Belgium, Denmark, France, Germany, The Netherlands, Norway, Spain and Switzerland. The UK is therefore only watching from the sidelines.

With the commencement of phase 2, units of hardware will be progressively launched into space, the first of these being a Russian Flight in November of 1997. The first main scientific unit launched into space will be the US lab during 1998, followed in 1999 by the first Russian laboratory. During the year 2000 the Japanese Experiment module and European facility will be implemented. Phase 3 essentially begins with the completion of the US laboratory facility.

At the completion of Phase 3, the station will be fully functional across the range of its operations. On the research side these will include the microgravity research laboratories, orbital research platforms and multi user experiment facilities supported by a worldwide distributed ground systems network for data distribution. The revised plan for the Space Station represents a major achievement of international scientific co-operation. Its core philosophy is to try to reduce duplication of effort in space technology. There has since been minor alterations of plans during the Spring of 1996 - the deployment of the Japanese module will be delayed and the European module not flown till 2003.

In NASA's literature on the Space Station there is a very definite and futuristic view put on the station's development:

"The resulting research program will position the international partnership for dramatic achievements in space exploration, technology development and quality of life improvements on Earth in the 21st century."

The incorporation of Russian technology into the International Space Station has allowed a better station to be built more rapidly and for less money. The power available will be 110 kW compared initially with 56 kW, the pressurised volume to 42.4 thousand cubic feet (equivalent to two Jumbo jets) compared with initially 23 thousand cubic feet, the number of laboratory modules six compared to three and six full time crew compared with four initially. The important propulsion unit will be built by Russia and will periodically boost the Space Station to maintain its orbital height of 248 miles. The decay of orbit is the result of drag of the station in the traces of the upper atmosphere.

The vast scale of the Space Station initiative is also forcing the development of Systems Management technology to ensure that procedures take place in a planned and timely framework.

Figure 4 shows an artist's impression of the completed International Space Station and with figure 5 providing the key to identify its main components. When completed, the total mass of the station will be around 400 tonnes.

Planned international utilisation

In some ways the plan of the utilisation of the Space Station outlined in figure 6 is like a snapshot of the main economic power blocks of the world. It is evident, however, that Russia scores most points overall for encompassing the diverse sets of Science Disciplines to the highest degree.

The Russian component of Earth Sciences is the most developed, as is its Engineering and Technology development. What Russia appears to lack, however, is the ability to translate the advanced state of this technology to conventional industrial outlets. It has difficulty transferring this technology into commercial markets.

It is the USA, however, that is most dedicated to the Life and Microgravity Sciences range of topics. This is probably also related to mapping scientific activity to those sectors that probably have the greatest commercial potential. It is also evident that the USA's activity in this sector is closely matched by that of Japan but that Europe's involvement is at best some way behind.

Figure 6: Planned utilisation of the Space Station according to scientific disciplines

	SCIENCE DISCIPLINE	CANADA	EUROPE	JAPAN	RUSSIA	USA
EARTH SCIENCES	ATMOSPHERIC	◔	◒	◔	●	●
	EARTH'S SURFACE	○	◒	○	●	◔
	MAGNETOSPHERIC AND IONOSPHERIC PHYSICS	○	●	○		◔
	METEOROLOGICAL	○	◔	◔	●	◔
ENGINEERING AND TECHNOLOGY DEVELOPMENT	ADVANCED LIFE SUPPORT	○	◔	◔	●	◔
	COMMUNICATIONS	○	○	◔	◒	◒ £
	INSTRUMENT SYSTEMS	●	○ £	◔		◒ £
	MATERIALS EXPOSURE	●	●	●	●	● £
	POWER GENERATION AND STORAGE	○	◒	◔	●	●
	PROPULSION	○	○	◔	●	◔
	ROBOTICS AND REMOTE OPERATIONS	●	◒	◔	●	◒
	SPACECRAFT SYSTEMS		◔	◒		◒
LIFE AND MICROGRAVITY SCIENCES	BIOMEDICAL SCIENCE	●	◒ £	●	●	● £
	BIOTECHNOLOGY	◔	◔ £	● £	●	● £
	COMBUSTIOON SCIENCE	◔	◔ £	◔ £	◔	●
	FLUID PHYSICS	●	◒	● £	◔	●
	GRAVITATIONAL BIOLOGY	●	◒	● £	●	● £
	MATERIALS SCIENCE	●	◒ £	● £	●	● £
	MICROGRAVITY PHYSICS	◔	◔	● £		◒
SPACE SCIENCES	HIGH ENERGY ASTROPHYSICS	○	◔	◒	●	●
	SOLAR OBSERVATIONS	○	●	◔	◔	◔
	SOLAR SYSTEM/PLANETARY STUDIES	○	●	○	◔	◔

○ INTEREST (NO CONCEPTUAL PROGRAMME)
◔ CONCEPTUAL PROGRAMME (PLANNING ONLY)
◒ CONCEPTUAL PROGRAMME (NEW DESIGN OR MODIFICATION OF EXISTING HARDWARE)
● MATURE PROGRAMME
£ COMMERCIAL INVOLVEMENT

Public outreach: enter KidSat

A key aim of the Space Station initiative is to open out its sphere of influence. Already, for example, the 'KidSat' project is being structured to allow children to design and monitor experiments taken up to the Space Station to monitor environmental data in their own 'backyard'.

Enhancing the Shuttle

The Space Shuttle was designed in the 1960s, built in the 1970s and has flown for the past 15 years. The existing Shuttle fleet is being slowly upgraded to improve reliability, improve payload capacity and reduce servicing costs as a prelude to its future role in assembling the International Space Station. A key area is that of engines design where increased thrust is being sought but with improved safety and ease of construction of critical high pressure components. There is also a planned reduction in thermal insulation and upgrading of on-board electronics. A weight reduction of the vehicle of at least 4 or 5 tonnes in anticipated.

Science in the skies

The focus of a large financial investment in the science of the Space Station has helped refine a framework of proposed scientific investigation. It is in some ways refreshing to see that the planned applications can be seen as 'helpful' rather than 'unhelpful' as with previous Star Wars technology.

Biotechnology

One of the more promising areas identified for Space Station research is that of Biotechnology. As a 'sunrise' industry but with a rapidly developing economic value, the unique environment of the Space Station is seen by some workers as an exciting opportunity to make significant advances.

In the body cells produce around 75,000 different proteins that are involved in a multitude of different processes such as oxygen transport, skin growth and the immune system. The identification of key human proteins is claimed to be the cornerstone of future radical medical discoveries. It is anticipated that the micro-gravity crystal growth facilities of the Space Station will accelerate significantly the pace of such medical developments as terrestrial based x-ray diffraction yields up the secrets of their molecular structure.

The requirement for high quality samples is usually, however, an on going necessity where key research projects require specimens for periods of several years. The Space Station will be specifically geared to producing a range of crystals for extended periods. Major drug companies such as Upjohn, DuPont, Merck and Smith Kline Beecham have already become involved in NASA's Center for Macromolecular Crystallography where Space Shuttle missions have been used to produce superior protein crystals for x-ray analysis.

Topics already being investigated include the development of a more effective form of insulin and a factor in the structure of the replication enzyme of the AIDS virus. Relevant work with the Shuttle has to date also included studies of Gamma-interferon (anti-viral research), Porcine Elastase (emphysema), Malic enzyme (anti-parasitic drugs) and Factor D (immune system).

Tissue cultures

In some ways NASA is moving from the organisation that simply puts vehicles into space to one which is involved in developing the very science that its technology makes possible. Part of the logic of this is to obtain royalties from products which in turn will supplement its budget. There is, for example, significant interest in the tissue culturing in space. While the technology of tissue culturing has developed significantly on earth, Shuttle experiments have indicated that human cells behave somewhat differently in the conditions of space.

In anticipation of the Space Station developments, NASA has already developed a range of so-called bio-reactors to culture human tissues. These operate under terrestrial gravity but isolate cells from the surfaces on enclosing vessels. Work at present includes the growth of lung cells, intestine and cancer tumour cells. The interest with tumour cells is the prospect of being able to grow cell groupings which more closely resemble tumours in the human body and which can be more usefully tested using chemotherapy agents.

Space physiology

All earth based observations of physiology involve the study of the body while subject to gravity. While human physiology has been studied extensively in weightless conditions, especially for example on the Mir station, the Space Station will afford better scientific opportunities to undertake fundamentally new brain and nervous system research. NASA has, for example, undertaken initial work in mapping the location of neurons which are involved in gravity sensing.

Space physiology has been able to map the various neuro receptors involved in maintaining balance. Over 60% of the body's motor system is dedicated to muscles that resist the force of gravity - by way of activities such as sitting, standing and walking. It is likely that further additional research will significantly improve our understanding of such systems - leading to better management of conditions that lead, for example to loss of balance.

With an ageing population world wide, the problem of osteoporosis - the condition of bone loss - is receiving increasing attention. The environment of space acts to produce a much greater rate of bone mass loss as indicated in figure 7 where the rate of loss of astronauts in the first months in space is compared with the average bone loss in humans between the ages of 50 to 60.

For any long term space mission, the problem of bone loss is a major one. Without any counter measures, an astronaut will typically lose in the first 8 months of the flight what the average human would lose between the age of 50 and 60 years of age. In around 6 years in space, if this rate was maintained, the astronaut would lose 50% of his bone mass. The Space Station provides an opportunity for the continuation of research into this problem - with the hope that solutions will be found that will also benefit society at large.

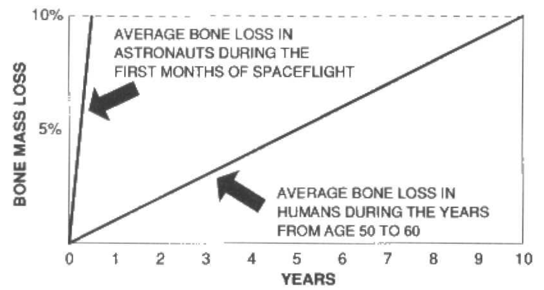


Figure 7: Relative loss of bone mass on earth and in space

To seek to minimise the negative effects of the space environment, NASA astronauts and Russian cosmonauts spend a part of each day exercising of stationery bikes and treadmills. It is difficult, however, in space to induce the gravity induced stressing forces that tend to maintain bone mass and also muscle mass. The understanding of this problem will also provide insight into the proper management of people on earth who are at risk through forced physical inactivity.

Biomedical research

In the wake of the immanent implementation of the Space Station, NASA has teamed up with the National Institute of Health (NIH) to develop a team approach to harnessing the scientific data in biomedical research gained form the Space Station. To date a total of 18 co-operative agreements have been drawn up. The first visible fruit of such co-operation should be evident in the form of the Neurolab Shuttle mission to be flown during March 1998. This approach is aimed at recovering as much as possible of the USA's investment in the Space Station in the form of highly marketable high technology products. It is by no means clear, however, if the European connection of the Space Station is so highly geared to commercial exploitation.

NASA has already, for example, produced an implant for delivering insulin for diabetes that is just three inches in diameter and includes a microcomputer, battery, insulin reservoir and pump. The unit can be refilled by using a syringe.

Telemedicine

The field of telemedicine has developed as a direct requirement of ground control to monitor the health of crew in space. Both NASA and the Russian Space Agency have many years of such experience. It is anticipated, however, that the transmission of medical data in the form of scan images/and physical monitoring of ecg, eeg and associated physiological waveforms will become increasingly important as centres of excellence of medical diagnosis are empowered to come 'on-line' to the world. The development of Telemedicine during the Space Station mission is yet another example of NASA showing the way in the more general applications of Telemedicine.

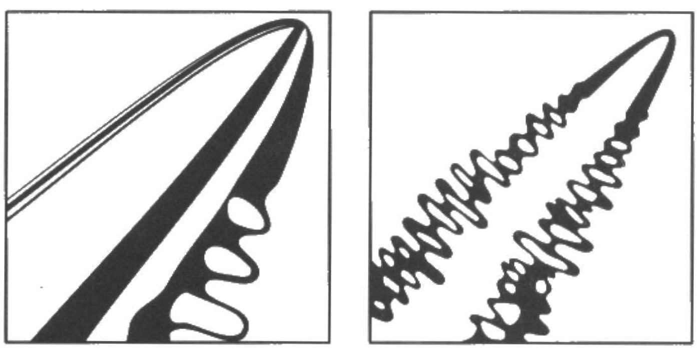
One of the spinoff developments of the Space Station is the development by NASA of the 'Clinical Practice Library of Medicine' or 'System 2000' in association with the University of Florida at Gainesville. This system is now entering limited clinical trials at several doctors' offices and also at various NASA centres. Such a system is likely to have widespread applications in both the teaching of medicine and in its clinical practice.

Developing materials science

A key part of technology relates to the development and use of advanced materials. It is anticipated that the access to the micro-gravity environment of the Space Station will provide an opportunity to better understand the fundamentals of the structure of materials where previously the presence of gravity has obscured inherent processes. Typical materials being studied range from glass and steel to semiconductors and plastics.

It is only being realised what a significant effect gravity has on a wide range of processes involved in the production of materials. Processes involving the crystallisation of materials typically involve 'dendrite' crystal growth. In space, however, dendritic development is more pronounced and alters the set of characteristics of the material as indicated in figure 8. Space appears to be providing a more chaotic environment for such processes.

Figure 8: Comparison of 'dendrite' crystal grown on earth (left) and a comparable crystal grown on board the Space Shuttle (right)



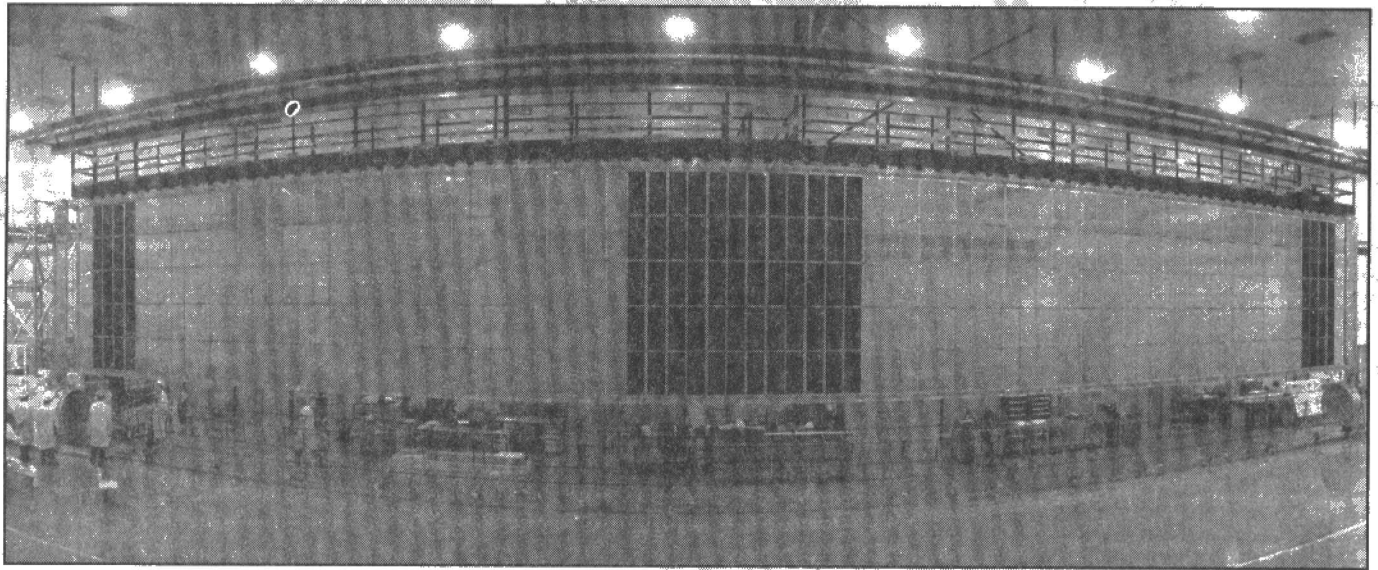


Figure 9: A fisheye lens picture of an early prototype construction of a solar array for the Space Station, built at Lockheed Martin Missiles, Sunnyvale, California

Combustion science

The process of combustion still accounts for some 85% of the world's energy production. Any significant improvements in the efficiency of this process would translate directly to fuel saving and reduction of release of greenhouse gases.

Combustion studies on board the Space Shuttle have already provided a novel means of validating some of the most basic theories of combustion processes such as the Burke-Schumann model of gas jet diffusion. At the recent 25 th International Symposium on Combustion, almost 10% of papers presented related to low gravity combustion research.

The process of 'combustion synthesis' where valuable materials such as high strength carbon fibres, lightweight composites and fullerines are produced directly as a product of combustion is also currently being studied in low gravity environments.

When a candle is lit in space, it develops to form a spherical shape initially which is subsequently extinguished due to the lack of convection processes which supply fresh oxygen to the zone of combustion. This is because the heated air does not rise in space due to its reduced density as would be the case on earth.

Life on earth has basically developed in within the confines and limitations a the gravitational field of the earth. The removal of gravity introduces a radical alteration of a broad range of mechanisms for living organisms. It is this removal of gravity which allows a better understanding of the role of gravity as a regulatory factor in life sciences.

Advanced technology development

Support for the specialist systems required for the Space Station is expected to push significant investment into a broad range of technologies. The requirement to develop high efficiency and stable solar arrays for the Space Station project is likely to benefit in a general way the drive to develop more efficient and cost effective solar cell technology.

Significant investment is being directed towards the area of reliable robotic systems and systems for remote operations. Canada, for example, is involved in developing robot arm technology for loading/unloading of hardware to and from the Space Station.

In addition, significant developments are required for so called Advanced Extravehicular Activity (EVA) systems where astronauts may be required to spend long periods assembling and maintaining space vehicles.

The standard way of obtaining power in space has been to use solar cells. While this is essentially straightforward for single satellites and deep space probes, for the Space Station the size of array required is significant and as a consequence introduces atmospheric drag due to contact with residual traces of the atmosphere. At best, the photovoltaic system will demonstrate 25% efficiency. One option being assessed is to develop a thermodynamic solar generator where solar energy is focused onto absorbing surfaces and stored in a thermal storage reservoir from where it can be extracted as required in some kind of power generation system.

One of the problems of space technology is that evolution of systems can be a slow and deliberate process where even the best ground based simulation systems cannot fully match the harsh conditions experienced in outer space. The Space Station will provide the opportunity for prototype component systems to be exposed to the harsh environment of space and then returned to earth for assessment and verification of function. This should accelerate the rate of development of space technology and confirm the trend towards smaller, more reliable spacecraft. Will this mean that those countries not participating in the Space Station project will miss out on developments at this cutting edge of technology?

Life support

A critical part of the Space Station technology will be its life support systems which maintain a breathable atmosphere, regulate the temperature of inhabited modules and also where possible recycle waste products. The development of this technology is expected to make available vastly improved air and water quality sensors in order to monitor and regulate processes adequately.

The dramatically reduced availability of water in space will drive technologies that will also benefit water utilisation on earth - especially in regions of drought.

It is widely recognised that the existing life support systems for space missions are not sufficiently developed to sustain longer missions to Mars and beyond. The expected migration

of this technology - based on that of the Russian Mir space station will be one of the key results to emerge from the Space Station project.

A scientific observatory

The long term exposure to crew on the Space Station will provide an opportunity to study at close hand the effects due to ionising radiation. This is also an important consideration for any future exploration of the solar system and beyond.

A range of more formal experiments will be undertaken using the Space Station and are planned to include studies of high energy astrophysics (cosmic rays), solar observations, and analysis of cosmic dust. The inherent value of the Space Station is that it provides a long lived platform within which varying phenomenon, such as the level of solar radiance, can be monitored.

The commercial aspect

With the Space Station there is a very clear move towards securing commercial interest in its range of scientific experiments. This is of course designed towards reducing the demands on the public purse. There is never, of course any certainty that any amount of funds will necessarily offer up scientific results which are of significant commercial value. The scientists may end up having the time of their lives and build their scientific careers on the vast swaths of data that emerge. But as to the inherent commercial value of what emerges, this is very certainly a gamble.

Some scientists are worried, however, that the large budgets set against the Space Station can only be sustained by reducing funding of Science elsewhere.

In reflection

The technology developed for the Space Station is primarily intended to maintain momentum in the reach-out of mankind into space. The planned rejuvenation of terrestrial science that is promised to follow this venture is something of an unknown quantity. Even Christopher Columbus's voyage was never expected to bear much fruit. Perhaps the greatest achievement, however, is the working together of diverse groups on a common peaceful implementation of science and technology and with the fear of world wide conflict removed.

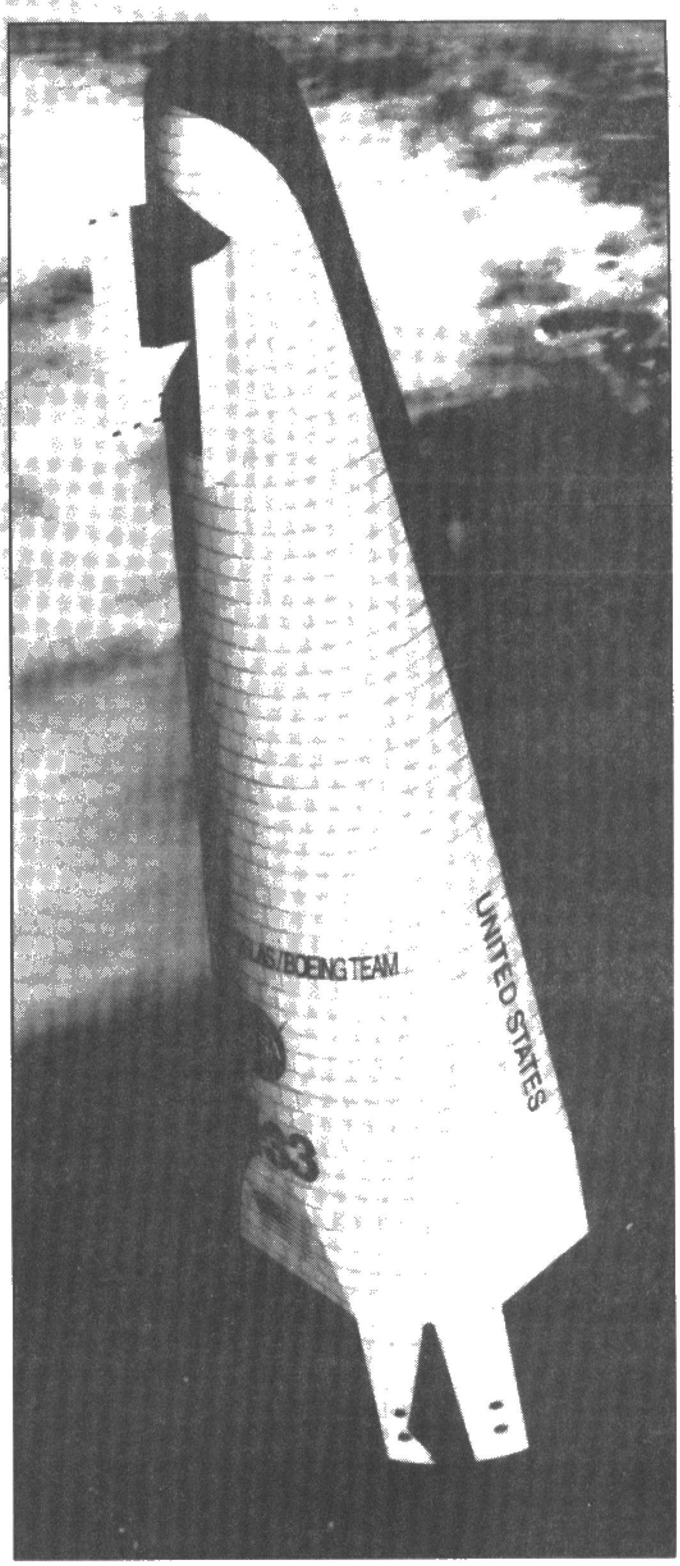
What is something of a disappointment, however, is the low profile of the present generally successful Shuttle/Mir encounters in the Media. It seems that something has to go dreadfully wrong before the hard work of space development comes into the public domain.

It is respectful to remember, however, the early difficulties of the Russian space station initiative and the dogged determination to perfect technology and succeed. There is no doubt that the International Space Station can be a technological success. This could very well act as a catalyst for scientists and technologists on terra firma to work under common initiatives on the many problems confronting mankind now and in the future.

Points of contact:

Information Services Center, NASA, Lyndon B. Johnson Space Center, 2101 NASA Road 1, Houston, Texas, 77058-3696, USA.

Center for Aerospace Information, Technology Transfer Office, 800 Elkridge Landing Road, Linthicum Heights, MD 21090, USA. Tel 001 301 859 5300 ext 245.



The Internet

Just search under space station and see what happens! Their number is legion. Some specific contacts are:

ISS White Papers -http://issa-www.jsc.nasa.gov/ss/prgview/sswp.html

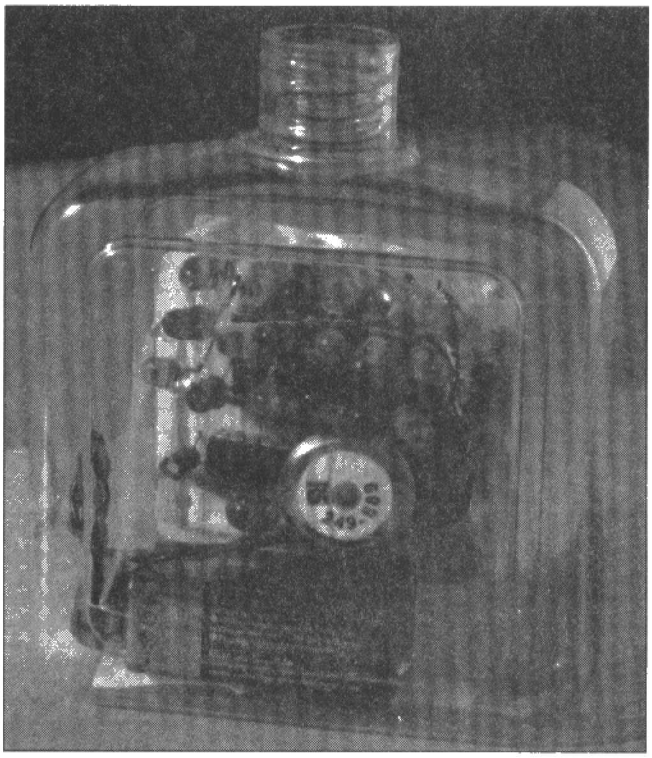
International Space Station (official) - http://liftoff.msfc.nasa.gov/station/welcome.html

ISS Bulletin Board -http://issa-www.jsc.nasa.gov/ss/spacestation_v2.shtml

The *ETI* Startler

What do you call a gadget whose only function is to surprise people? It's a startler!

Being as it is the Christmas season, it is not too out of order to give your nearest and dearest a mild surprise with their Christmas port. You may even be able to convince people that they have had too much to drink by fitting the following little project into an appropriate bottle. A gin bottle that bleeps and flashes may not be so traditional as pink elephants, but the message should be clear.



What the Startler does is to flash strings of LEDs while generating a varying - let us be frank, and call it a "weebling" - tone from a piezoelectric sounder, whenever it is disturbed. The prototype uses a tilt switch, set at such an angle that it would start the device off at the slightest vibration. (This was so successful that for a while, every time the front door opened, off it went ...) An alternative that we also tried is to use a momentary action pushbutton mounted on the bottom of a case so that the weight of the case holds the switch closed. Picking up the gadget will then trigger off the sound and light display. This works less well with very light cases like our soap-bottle.

How it works

The device contains two oscillators and a counter. The first oscillator clocks the counter round, flashing the leds and varying the voltage fed to the second oscillator.

The second oscillator works at a higher frequency, and generates audio frequencies which are heard in the sounder. Its frequency is varied by the voltage fed to it by the resistors connected to the counter.

When power is first applied, and assuming SW1 is closed, the following sequence of events takes place:

Initially C2 is uncharged, so that IC2a pin 1 is taken to logic 1, while IC2b pin 6 is held to the logic level on IC2a pin 3. Because pin 1 is held to a high enough voltage to pass as logic 1 for several seconds, normally the bistable will start with pin 3 low and pin 4 high. Any glitch at all on pin 3 at power up will set the bistable into this mode.

This probable startup mode is the run condition. IC2c pin 9 being held low forces the output on pin 10 to logic 1, which enables both oscillators and removes the reset signal from the counter.

IC3 a and b form a low frequency clock oscillator which makes IC1 count slowly enough for the individual steps to be visible and audible. The counter outputs drive chains of LEDs whose operating current is determined by the current limiting on the output of IC1. The same counter outputs also vary the voltage applied to the timing point of the second oscillator, formed from IC3 c and d. This varies the frequency of the oscillation to give a characteristic weebling noise from the sounder.

This continues until C2 charges via R1 so that the voltage on IC2 pin 1 is low enough to be interpreted as logic 0, at which point the bistable flips to its other state.

This is the signal to stop the counting and the weebling, but in order to complete the sequence rather than have it stop in the middle, the Q0 signal from the counter is gated with the output of the bistable so that the oscillators are not stopped, and the reset signal not applied, until a defined counter state. Of course, when the counter is reset, Q0 goes to logic 1 anyway, so that the reset state is not disturbed until overridden by the bistable.

Assuming that the switch remains closed for a while, C2 now discharges so that IC2 pin 1 is at logic 1. If the switch is then opened for just a moment, the state of the bistable changes because R2 pulls IC2 pin 6 to logic 0, and flips the state of the bistable. This starts the above sequence again.

The sounder is a high-impedance device, and is driven from the output of a CMOS gate. DC blocking is provided by C5, with a DC bleed resistor, R14, avoiding the possiblity of any standing DC on the sounder, because some piezo-ceramic devices can fail if DC is applied for long periods.

The choice is yours

Several choices can be made at the time of assembling the unit. First of all, the time for which it bleeps at you after which you pick it up may be altered by choosing the value of C2 appropriately. The schematic shows a 470nF polyester capacitor, which will give an operating time about 3 seconds. Increasing this to 1uF to roughly double the operating time is possible while sticking with a non-polarised capacitor , but for higher values it will probably be more convenient to use tantalum or electrolytic capacitors. A radial electrolytic can be fitted in the space if its wires are bent outwards to line up with the PCB holes.

The specified leakage current for an electrolytic capacitor is too high to permit it to function in this application, but in practice the majority of electrolytics and virtually all tantalum bead capacitors will actually work. The prototype was deemed

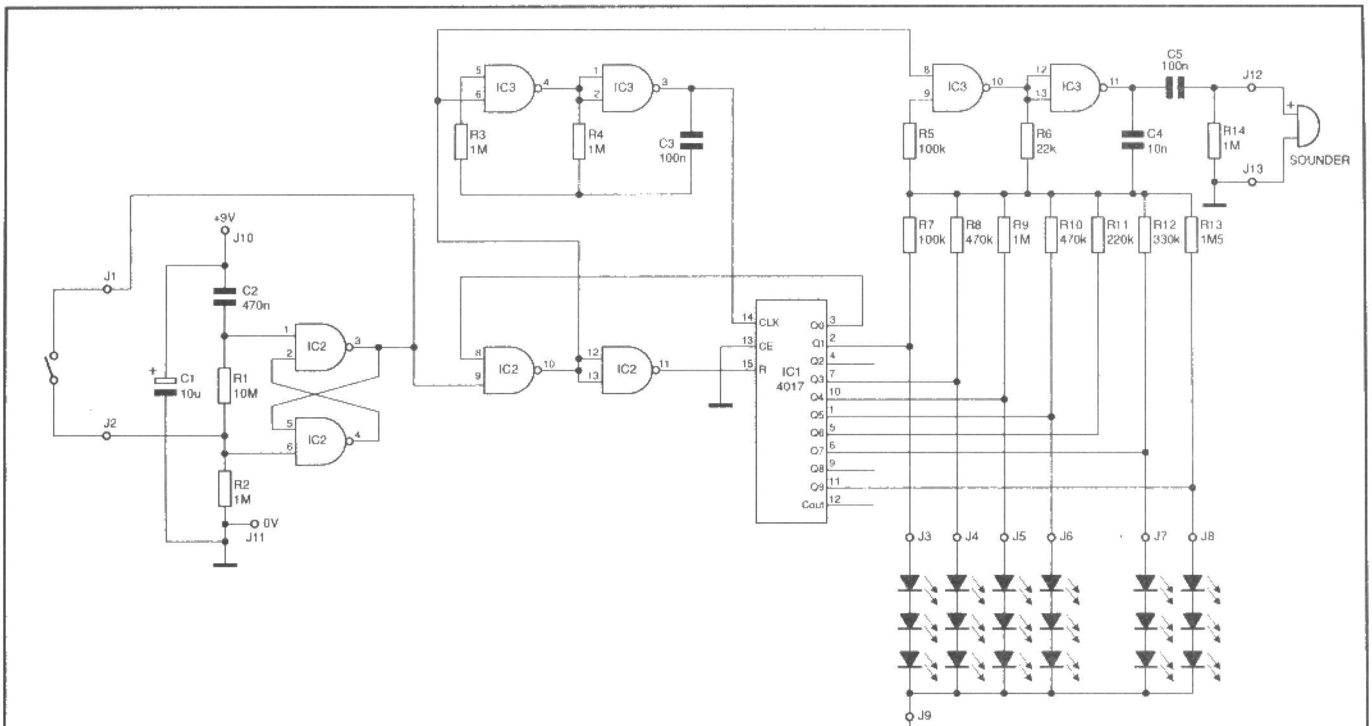


Figure 1: the circuit of the Startler

not to be irritating enough, so the 470nF capacitor was replaced by a 4u7 electrolytic, which works perfectly well and gives a weebling time of about 30 seconds.

The sequence of frequencies played can be altered by changing the values of one or more of the resistors which control the frequency, that is, R7 to R13 inclusive. Values below about 100k tend to stop the oscillator, so there is a limited range of control available. Equally, the colours for the LEDs can be chosen to give a pleasing pattern. Typically, it is better to stick to red, yellow and green LEDs, but if blue LEDs are to be used, then because these have a higher voltage drop than the other colours, it will probably be necessary to use one blue LED in series with one other colour, instead of using the normal 3 LEDs in the chain.

The unit is designed to be used with the wide-frequency Electromail sounder given in the Parts List and has not been tested for any other bleeper. It may work with other piezo-electric sounders, but there are few that give a range of frequencies, and the unit will not be so, shall we say, interesting with a mere single frequency.

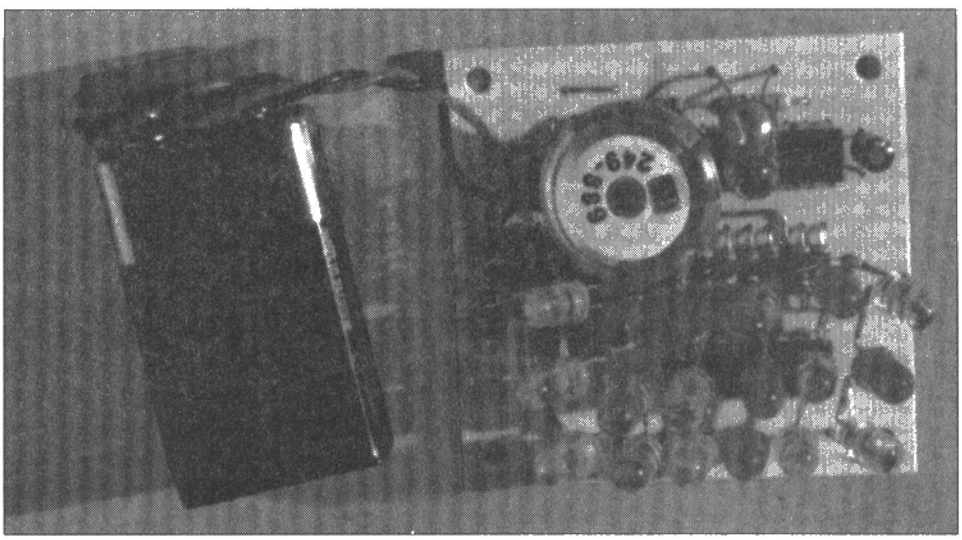
The unit is designed to be left on all the time, but you can if you wish add an on-off switch in series with the battery supply. This only makes the circuit wiring a little bit more conspicuous.

Assembling the PCB

Assembly should present no problems, simply follow the component layout and put the components in the appropriate places. Take note that there is one straight wire link and one with two bends in it. For the latter, it would probably be best to use insulated wire to avoid short circuits with other components.

All the ics go in the same way round, so if you see that one is reversed, so not switch on. Modern cmos is fairly static-resistant, but some minimal static precautions should be taken, because the humidity indoors is normally lower in winter because of the colder outdoor temperatures, and this means that static charges build up more easily. Static damage to a cmos ic can leave the chip in working order but drawing much more power supply current than it should do. This would prove to be a particular annoyance in this unit, because the battery is left connected all the time (unless you have chosen to fit an on/off switch.

Before fitting the leds, it is necessary to decide what the unit is to be mounted in. Assuming that it is to be built in a small plastic container like the prototype, then the LEDs can be strung across the top of the PCB, supported safely above the other components on their own wires. It is probably best to connect the LEDs in chains forst of all, leaving the end-wires of each chain uncut. It is important to know which way round the LEDs are, and a good way to do this is to use a resistor in the range 1k to 4k7 and the PP3 battery on which



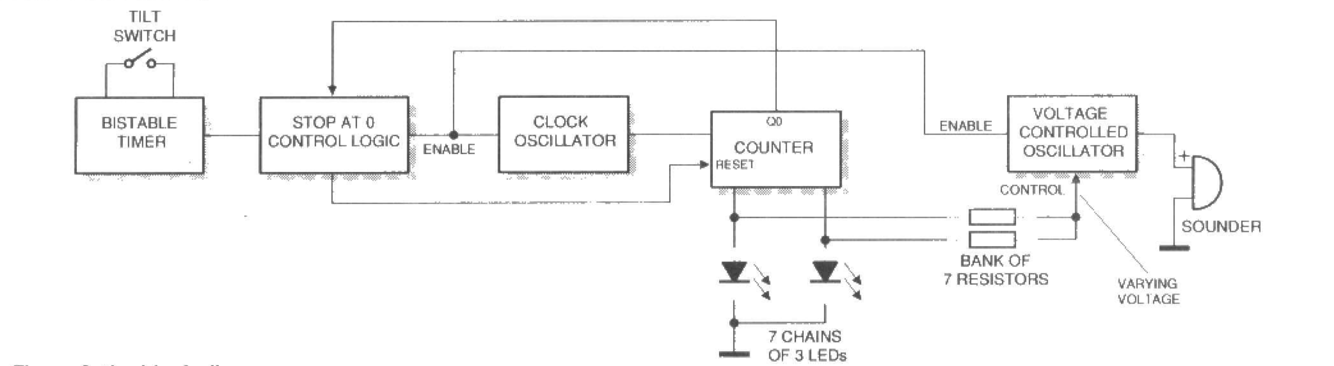


Figure 2: the block diagram

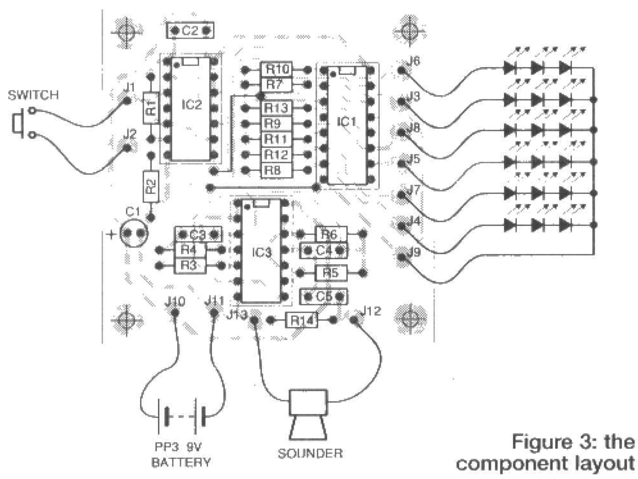


Figure 3: the component layout

the unit is to be run to power any LED that you want to check. Check each LED before connecting it into the chain, and then chekc the whole chain to make sure it works, and make a note of which end of the chain was connected to positive when the LEDs lit. This is the end which must be connected to one of the row of pads along the edge of the PCB, which connect back to the counter outputs. These pads are labelled J3 to J8 on the schematic.

In the prototype it was found effective to mount each LED chain to one of the LED output pads, leaving an appropriate length of wire to fit in the enclosure, then to join the wires at the other end together to form a common ground point. The ground point was finally linked back to J9 by means of a stiff piece of tinned copper wire in the final assembly. This gave a firm support for the LEDs.

Of course, the LEDs must be electrically in chains of three, but if you choose to wire up your chains on extension wires, you could put them almost anywhere, and hide the PCB anywhere that it might be disturbed. (Hiding in bowls of crisps or other eatables, of course, is not a good idea as solder dust is not good for the health, quite apart from salt damage to your carefully-constructed board.)

The sounder specified for use with this project has a metal frame which is connected to the ground of the sounder. As can be seen in the photograph, the sounder was supported by soldering one of its metal tabs to the common ground connection of the LEDs.

The tilt switch specified can be mounted straight onto the PCB between J1 and J2. When the PCB is fitted into a case, the wires of the tilt switch can be bent a little so that the switch remains normally closed but breaks contact very easily if the unit is disturbed or rocked.

Choice of case

The prototype unit was mounted in a transparent bottle which had once been a liquid-soap pump bottle. We wanted a transparent one, but you may find a translucent one more cryptic. The idea here was to peel off the label, cut a "door" for installation, and re-fix the label, covering the evidence. As an alternative, a little forethought would have resulted in my keeping one of those small plastic bottles in which alcoholic drinks are served on aeroplanes, an item more likely to be picked up if left lying around! The round wine bottles that they serve are (alas) not big enough for the board as laid out, but I have encountered drinks served in small rectangular-section bottled that could be pressed into service ... Or a small-sized plastic duty-free gin bottles may be suitable. But no doubt other possibilities will occur to you once you once you have built your "Startler".

PARTS LIST for the Startler

Resistors (all .25W 5% unless otherwise stated)

R1	10M
R2,R3,R4,R9,R14	1M
R5,R7	100k
R6	22k
R8,R10	470k
R11	220k
R12	330k
R13	1M5

Capacitors (All polyester 0.2in pitch unless otherwise stated)

C1	10uF 16V radial electro
0.1in	pitch
C2	470nF
C3,C5	100nF
C4	10nF

Semiconductors

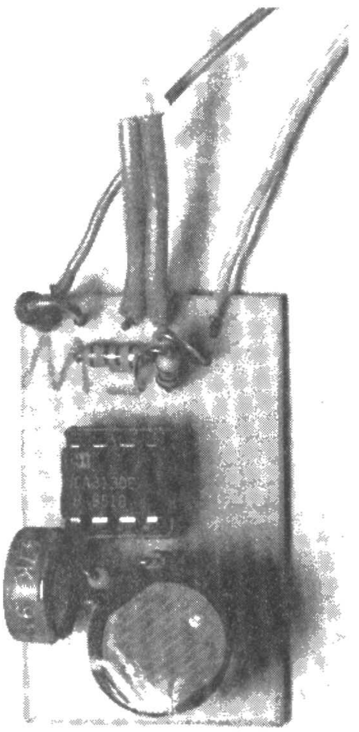
IC1	4017
IC2,CI3	4011
LEDs	18 in total, colours to your choice

Miscellaneous

Sounder (Electromail part no. 249889); PP3 battery clip; tilt switch (for example, Maplin part no. DP50E) or small pressure-sensitive switch; small on/off switch (optional), PP3 battery, insulated wire, solder, etc.

Rudolph's Nose

His nose glows and off he goes! By Terry Balbirnie



As everyone knows, Rudolph (Santa's leading reindeer) has a red nose which guides the sleigh at night. What many people do not know is that he rests during the daytime and then his nose goes green. It only warms up in the evening when he gets ready for duty.

Cut-up

Rudolph himself is best cut out of cardboard. Those with artistic ability could draw him themselves, or use an old Christmas card or colouring book cut-out as a basis. Some children might even make a three-dimensional model. Hidden behind him is a small circuit panel on which is mounted a two-colour (light-emitting diode) which must stick out where the nose is supposed to be. This may involve cutting out Rudolph's nose - we hope you have a steady hand! During daylight hours it glows green. However, as the light falls it suddenly becomes red and Rudolph is ready to go.

Although primarily intended for the amusement of children, Rudolph could be used as a talking point at any Christmas party. After a few drinks it is surprising how amusing his nose can be!

Rudolph's current requirement is about 50mA at 12V. This is too much for a battery to provide over a prolonged period, so the circuit has therefore been designed to operate from a commercial dc plug-in adaptor (preferably of the regulated type). If no mains supply is available, it would be possible to use eight "C" size alkaline cells in a suitable holder and these might be expected to give about 100 hours of service. Will your party last that long? Alternatively, two PJ996 6V "lantern" batteries could be connected in series.

The circuit

The full circuit diagram for Rudolph's Nose is shown in figure 1. The 12V supply provides current through diode D1, to protect the circuit against possible damage if the supply were connected with incorrect polarity. The sensor is a light-dependent resistor, LDR1. The resistance of this component rises as the light intensity falling on its window decreases. LDR1 forms the lower arm of a potential divider with fixed resistor, R1 and preset potentiometer, RV1 connected in series comprising the upper arm. Thus, as the light falling on the LDR sensitive surface falls, the voltage applied to operational amplifier, IC1, inverting input (pin 2), will rise. To illustrate the action, suppose RV1 is adjusted so that, under normal daylight conditions, the voltage applied to pin 2 is 5.5V and under darker ones, 6.5V.

A fixed voltage equal to one-half that of the supply (nominally 6V) is applied to the op-amp non-inverting input, pin 3, by the potential divider action of equal-value fixed resistors R2 and R3 (ignore the effect of R4 for the moment). Under daylight conditions, therefore, the voltage applied to the non-inverting input will exceed that at the inverting one. This will result in the output, pin 6, being high (positive supply voltage). In dim light, the conditions will reverse and the voltage at the inverting input will exceed that at the non-inverting one. The op-amp will then switch off with pin 6 going low. The point at which this transition occurs is controlled by RV1 and this may

Figure 1: The circuit for Rudolph's Nose

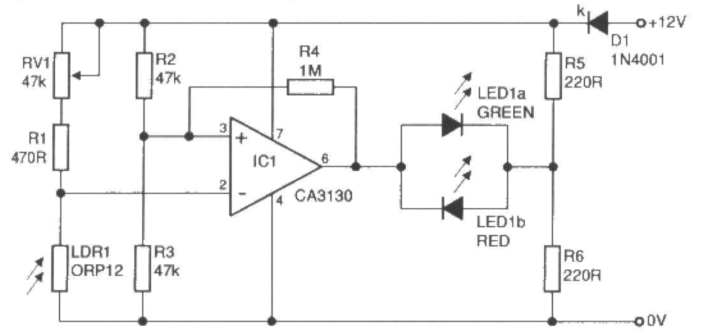
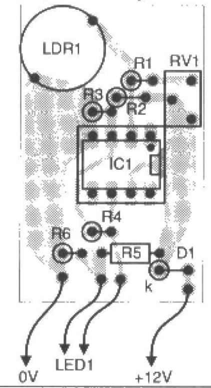


Figure 2: The component layout



be made to happen over a wide range of light levels.

Note that the light level at which the op-amp output switches from high to low does not depend on the supply voltage. This is because any rise or fall in it will be reflected equally in both op-amp inputs and the relative state will be unchanged.

Down the sink

Although light-emitting diode LED1 looks much the same as a standard component it is, in reality, two LEDs in one translucent package - one green (LED1a) and the other red (LED1b). These are connected together in inverse parallel: when current flows in one direction, the red LED will light and when it flows the other way, the green one will. When pin 6 is high (bright conditions), the op-amp acts as a source and current flows through the green LED section hence through resistor R6 to ground. When pin 6 is low (dim conditions) the op-amp acts as a sink and current flows through the red LED via resistor R5.

Resistor, R4, applies a little positive feedback to the system. This provides sharp switching and eliminates the possibility of flickering between the two LED sections around the critical light level. Resistor R1 prevents an excessive current from flowing through the LDR if RV1 were to be set to zero resistance with the LDR exposed to very bright light.

Construction

Construction of Rudolph's Nose is based on a single-sided printed circuit board (PCB) and the component overlay for this is shown in figure 2.

Begin by soldering the ic socket in position followed by the fixed resistors and RV1. Add the diode taking care over its polarity. The striped end is the cathode and is labelled "k" in the diagrams. Take note of the polarity of the LED. The slightly shorter lead will be connected to the upper pad on the PCB - that is, the one leading to IC1 pin 6. Cut the longer LED lead to the same length as the shorter one keeping note of which one is which. Sleeve the wires to prevent short-circuits and bend the end two millimetres of each through right angles. Solder these to the pads on the PCB using minimum heat to prevent damage. If the leads are connected in the wrong sense, the LED will glow green in the dark instead of red. This could be a problem for Rudolph!

Cut the LDR leads to a length of 12mm approximately and solder them to the PCB. This component is easily damaged by excessive heat so it would be wise to use a heat shunt. This may be done by gripping each wire in turn between the body of the device and the PCB with a pair of pliers as it is soldered. Solder wires to the "+12V" and "0V" battery supply pads and fit a 2.5mm line jack socket or appropriate connector for the battery or power supply unit being used.

Insert the ic into its holder taking care over the orientation. Since this is a static-sensitive CMOS component, it would be prudent to touch something earthed, like a water tap or a metal radiator - before handling it, to discharge your static charge. Adjust RV1 fully clockwise (as viewed from the edge of the PCB).

Checking Rudolph

Check the polarity of the power supply and make the connection accordingly. If it is connected incorrectly, diode D1 will block the flow of current and the circuit will not work. If the supply is of the 12V regulated type there will be no problem. If it is an unregulated one, it is suggested that the switched type be used. This will probably provide outputs of nominally 3, 4.5, 6, 7.5, 9 and 12V. With the relatively small load presented by this circuit, the output could be considerably greater than the nominal value. To overcome possible problems due to an excessive supply voltage, set the unit to 6V and switch on. Increase the output voltage until satisfactory operation is achieved. Alternatively, a voltmeter could be used to check the voltage while on load and the output increased so that about 12V is provided.

With the circuit operating in normal daylight, the green LED should be on. Shade the LDR with the hand - the LED should suddenly switch to red. If this test does not work, adjust RV1 until it does. Note that slightly more light is needed to switch back to green than was needed to switch to red. Such is the effect of feedback resistor, R4. If there is too much difference between these light levels, R4 could be increased in value and vice-versa. If, despite the precautions, the colours operate in the opposite sense, the LED leads will need to be reversed.

If all is well, the circuit panel should be fitted behind Rudolph with the LED leads bent as necessary to allow the lamp end to be pushed through the nose position. The circuit panel is light enough to be normally self-supporting. However, an adhesive fixing pad could be used if necessary. Resistors R5 and R6 become warm in operation. Care will need to be taken to ensure that overheating does not occur if the circuit panel is enclosed.

Place Rudolph so that the LDR receives direct light from a window rather than ambient light in the room. This will avoid the LED changing colour when the room lights are switched on and off. Placing the model on a window sill would be therefore ideal. Once in position RV1 is adjusted so that the LED changes colour at the required light level. Having done this, Rudolph should not be moved or RV1 will need to be re-adjusted.

Happy Christmas!

PARTS LIST for Rudolf

Resistors (All fixed resistors 0.6W 1%)

- R1 470R
- R2, R3 47k
- R4 1M
- R5, R6 220R
- LDR1 ORP12
- RV1 47k miniature vertical preset.

Semiconductors

- IC1 CA3130 op-amp
- D1 1N4001
- LED1 5mm bi-colour

Miscellaneous

12V 300 mA dc plug-in power supply unit or battery supply (see text).
Material for the model, etc.

Multicolour Christmas Light Chain

Bart Trepak has decided to throw away his blown-up lamps and "change over" to LEDs. They can move, flash - and even use lamps if that's your family favourite

There are many mysteries in our everyday lives which in spite of our scientific advances we seem to be no nearer to solving. Questions such as - why does toast always fall butter side down?.... or why does the most expensive and inaccessible component in a piece of equipment always blow first and protect the fuse?....or why do only other people's numbers come up in the National Lottery? ... have baffled philosophers, engineers and the general public since buttered toast was invented. One apparent mystery which exercises many people's minds around this time of the year is why do the Christmas tree lights which worked perfectly last year when they were taken down fail to work now even though they have not been used for a whole year?

The technical reason, if not its cause, is obvious. Since the lamps are wired in series, the failure of any one bulb or a poor connection in a bulb holder will prevent the whole string from lighting and the annual ritual of tightening the lamps in their holders or replacing each lamp in turn has to be re-enacted, the operator balanced precariously over a prickly tree hung with fragile glass ornaments - a process which can drive one to drink well before the festive season gets under way.

Some manufacturers have tried to overcome these difficulties by designing lamps to go "short circuit" when they fail and which do not therefore prevent the whole string from lighting. This however only serves to put off the problem and can even make it worse, as each of the remaining lamps is subjected to a greater fraction of the supply voltage and so tends to fail earlier, especially if the non-operation of a lamp is not noticed immediately. This means that by the time the failed lamp or lamps are replaced, the life of the working ones will have been severely reduced resulting in the extra exercise and expense of more frequent replacement of bulbs.

The low cost of LEDs has prompted some manufacturers to offer "Christmas tree lights that never fail" at prices outrageous to those of us who know the price of LEDs. LEDs are ideal for this application, and with blue LEDs now at more or less reasonable prices, the objection to using LEDs due to the limited range of colours is no longer valid. The relatively low brightness of LEDs compared to lamps is not a serious drawback, and since they do not fail like lamps they can be soldered permanently into a chain, removing the need for those unreliable holders. Their low forward volt drop means that strings of 50 or more can easily be made to operate from the mains, provided of course that the current is limited to a suitable value of less than 20mA. A hundred LEDs of various

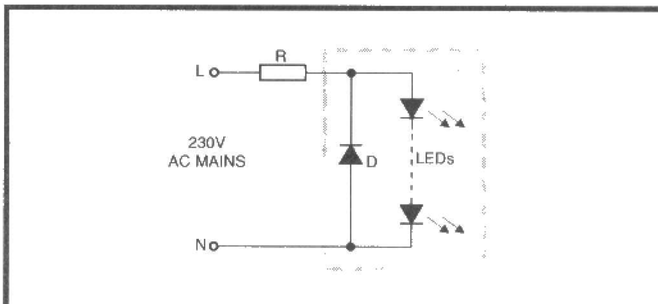


Figure 1:the LED mains drive circuit

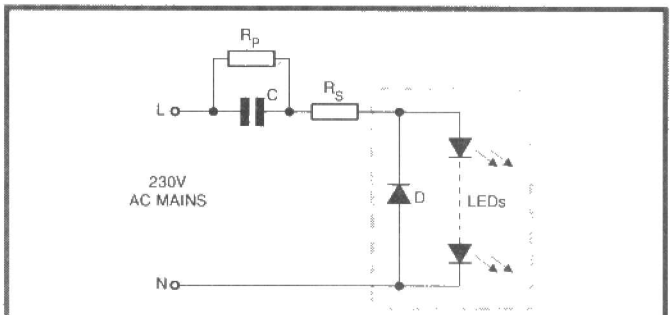


Figure 2a: the improved LED mains drive circuit

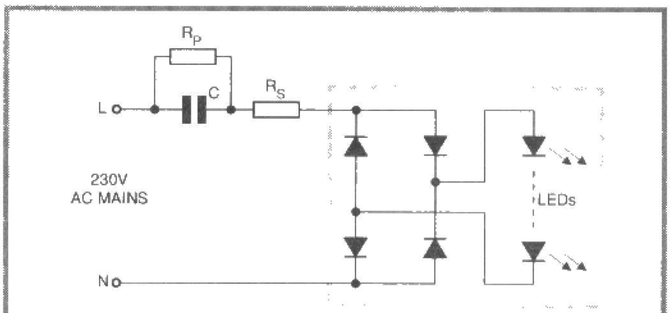


Figure 2b: full wave LED mains drive circuit

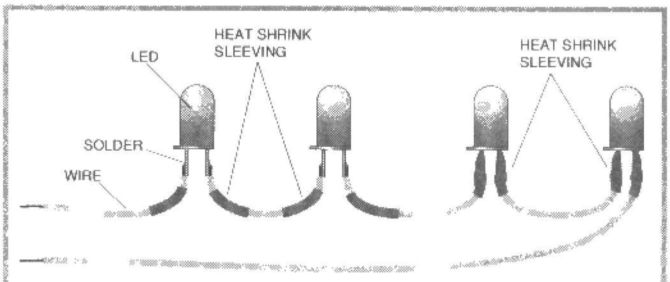


Figure 3: constructing the LED chain

Figure 4: the circuit of a Christmas tree light flasher

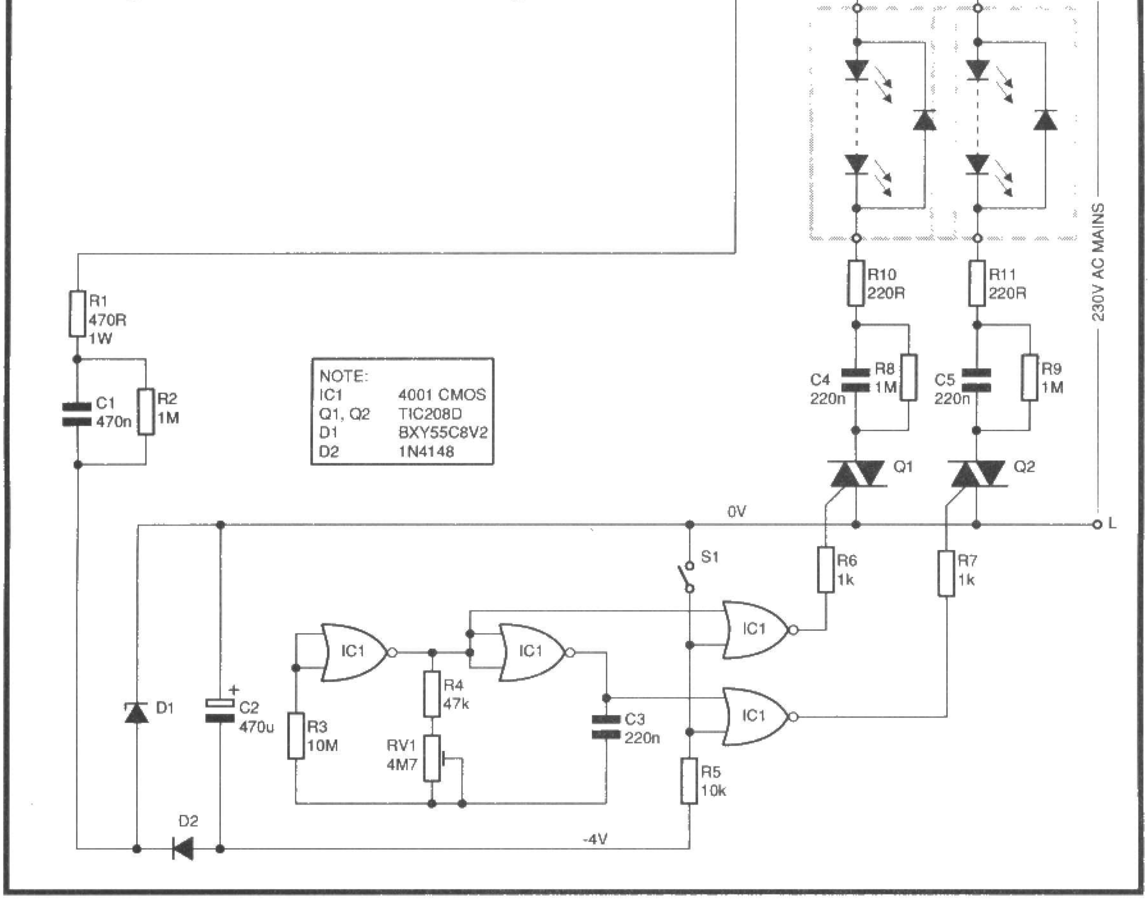
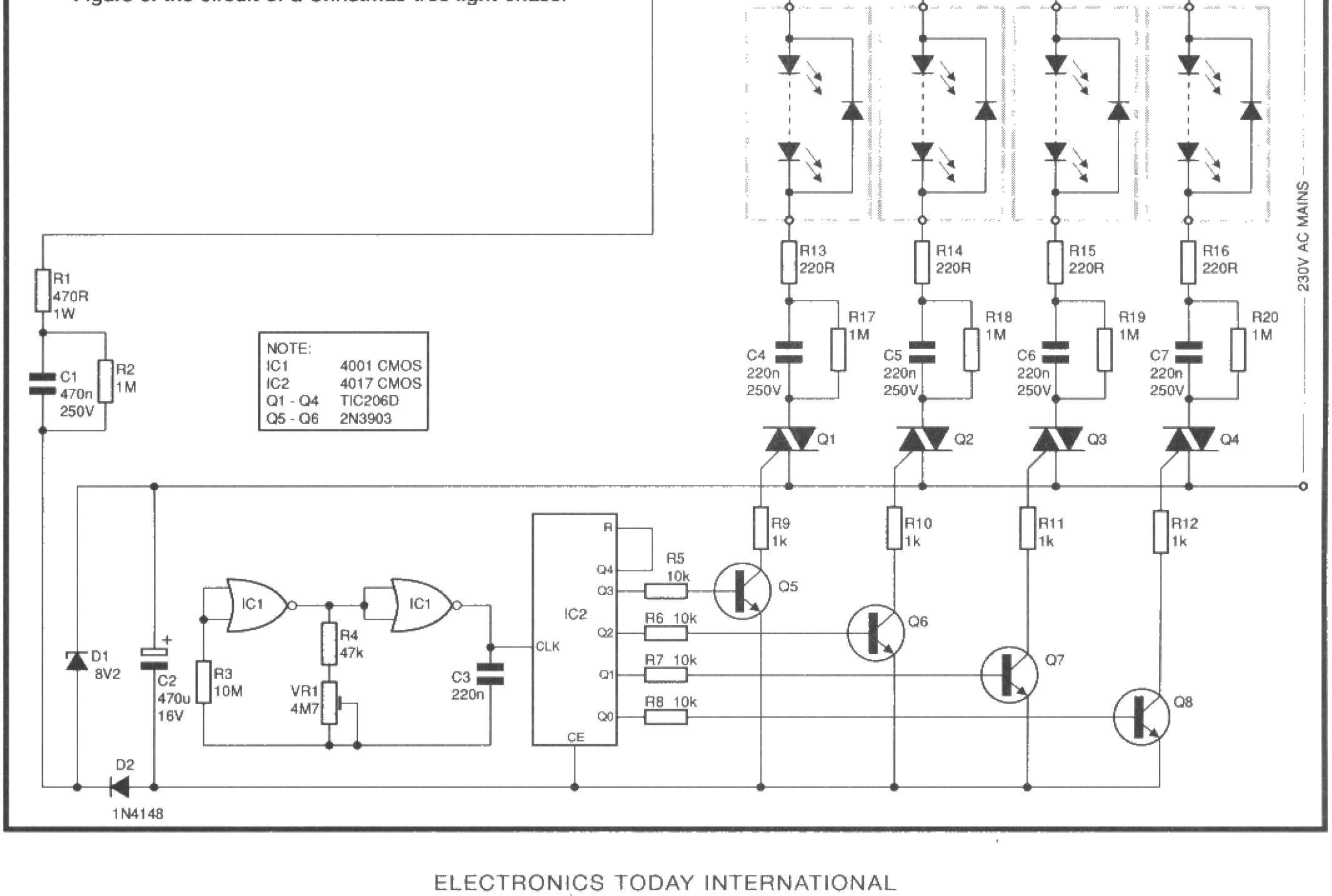


Figure 5: the circuit of a Christmas tree light chaser



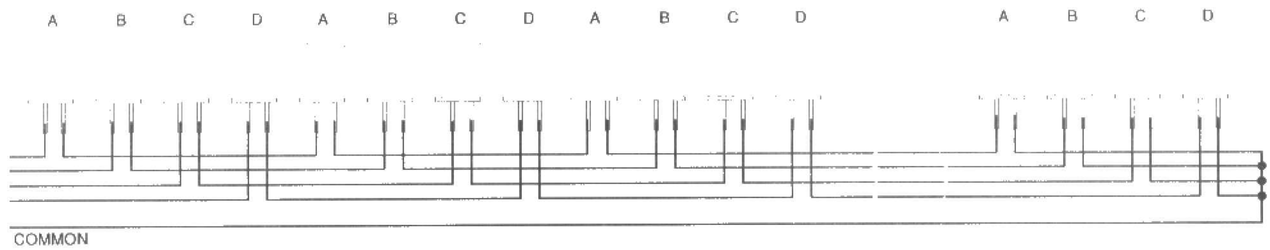


Figure 6: positioning the LED strings to obtain a "chase" effect

colours can easily be purchased for about £10 - £15 (as long as there are not too many blue ones) and neglecting the cost of wiring them which is part of the fun of electronics (isn't it?), this compares quite favourably with commercial lights consisting of perhaps 20 lamps. Even buying the larger 8 or 10mm LEDs would only cost marginally more.

I therefore decided to replace all my Christmas tree lights once and for all, and ordered the LEDs, when it occurred to me that LEDs are not the only components that have come down in price and a simple string of lights which remain On is rather boring. Making them flash would make for a far more interesting display.

Simple lights

For those who simply want to avoid the annual chore of trying to get the Christmas tree lights to work, the circuit in figure 1 is the simplest possible. In theory all that is needed to run a string of LEDs from the mains is a resistor to limit the current and a diode to protect the LEDs against too high a reverse voltage. A transformer could be used to give isolation and reduce the voltage, but as it is not normally used on ordinary tree lights it was not considered necessary. The resistor will need to be about 10kohm with a power rating of 5 watts, so that the box holding this component will need to be large and well ventilated.

A much better solution is to use a capacitor instead of a resistor (as shown in figure 2) to drop the voltage as this would dissipate no power. If a small enough capacitor can be found, it may even be possible to fit it in the plug itself removing the need for a box. A value of 100nF would give an LED current of around 7 mA, while 220nF could be used if a brighter display was required. The capacitor must be rated at mains voltage (250V ac class X type) but the diode need only have a reverse voltage rating of 30V or slightly greater than the forward voltage of the chain. Note also that the diode could be replaced by another string of LEDs connected in inverse parallel, thus saving the cost of another capacitor if two chains are to be used.

Alternatively, the apparent brightness could be increased by connecting the chain inside a bridge rectifier as shown in figure 2a. In this case, the diodes would only need to have a reverse voltage greater than the forward voltage drop of the chain so that in most cases, any small signal silicon diodes such as 1N4148s could be used. Although the number of LEDs is not specified, any number of LEDs up to about 40 could be connected with no modification to the component values.

There is also no reason why only red LEDs should be used and to make the display more festive, amber, yellow, green and blue ones could be connected in place of some of the LEDs shown with no modifications to the circuit. It should be remembered however, that green and yellow LEDs are generally less bright and blue ones very much so compared to a red device passing the same current and since the current in this circuit is determined by the value of the capacitor all the LEDs may not appear equally bright. This is not too important in this application but if you insist on this then it would be better not to mix colours but to drive them from separate capacitors and adjust the values to give a more uniform brightness.

Construction

The LED chains can be made up using ordinary flexible wire which is first cut into lengths of about 30 cm. The insulation is then stripped back 5mm at each end and the ends tinned. Cut the leads of each LED down to about 5mm as shown in figure 3 but note first which end is the cathode and which the anode of the device. On most devices, the shorter lead is the cathode but once the leads are cut, it is of course impossible to determine this. Many devices have a small flattened area on the flange adjacent to the cathode so that this may be used, although some LEDs notably the 3mm types do not have this. People not prone to eyestrain have been known to identify the "way round" of LEDs by peering at their internal structure through the plastic, but I don't recommend this unless you are stuck, as you may end up with a squint. Slip 1-cm lengths of 3 or 4mm diameter heat shrink sleeving onto the wire and solder the tinned wire to the LED lead. It is easier if the LED is held lightly clamped in a vice while this is done. Take care not to overtighten the vice (or you may crack the LED), and complete the soldering operation as quickly as possible to avoid heat damage.

After you have soldered the required number of LEDs together, connect a wire of about 1 to 2 metres to the last one remembering to slip on a piece of heat shrink sleeving. Solder a suitable length of another colour of wire to the first LED so that the two free ends are about the same length. The length will of course be determined by the number of LEDs in the chain, their distance apart and the length of the other lead. Dark colour wires such as black, green or brown should be chosen so that they will not be too conspicuous on the Christmas tree. (Unless, of course, you are illuminating one of those silver tinsel trees ...)

Once this has been done, a capacitor and diode or diodes should be connected to the chain as shown in figure 2 or 2a, or another chain of LEDs connected in inverse parallel. It is also a good idea to fit resistor R1 across the capacitor to discharge it when it is disconnected from the mains. The value is not too important but should be between about 470k and 2M2 to ensure that it does not pass too much current but does not take too long to discharge the capacitor. Resistor R2 is also a sensible precaution and its purpose is to limit any initial surge current when the capacitor is discharged. A value of between 220 ohms and 1k is suitable here with a power rating of around 0.5 watt depending on the value of the

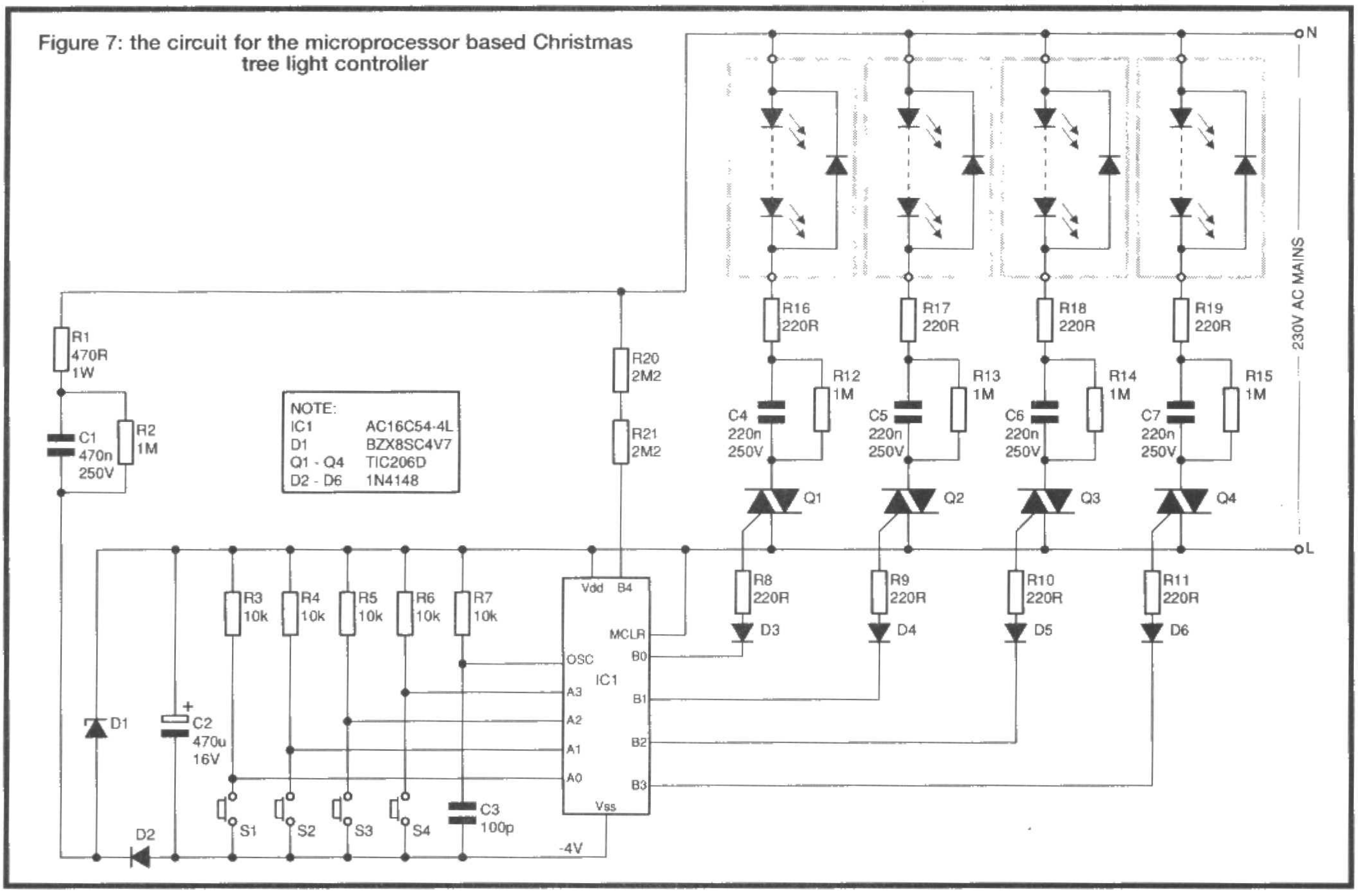


Figure 7: the circuit for the microprocessor based Christmas tree light controller

capacitor. The chain can now be connected to the mains to make sure that it lights. Failure of the chain to light will probably be due to a diode being reversed and if this is found, the unit should be disconnected and the fault repaired.

Once all the LEDs in the chain light, the heat shrink sleeving should be pulled over the LED leads and solder joints and shrunk using a hot air gun. When this has been done, the wires should be twisted to form one cable. This is best done by securing one end of the chain (just behind the leads of the first LED as shown in figure 3 and putting the other into the chuck of a wheel brace or a very slowly rotating drill. It can also be done by hand but is a long and boring process.

The wires could be further disguised by including some tinsel in the chain before it is twisted thus creating an "all in one" Christmas tree decoration. A tree could then be decorated quickly by simply hanging up the lights and adding a few baubles leaving more time to enjoy the festivities!

Do note, however, that mains voltages could be present on the LED chains, if the neutral connection to any one fails, or in the case of reversed mains plug connection. Therefore care should be taken to ensure that the insulation covers all of the LED wire, and as an extra precaution, if possible, the whole chain should be slipped into a transparent tube. It would also be a good safety feature to power this through an RCD safety trip.

A flash in the pan?

As mentioned, the display could be made more interesting by connecting a flasher circuit to the chain as shown in figure 4. This would cause the LEDs to flash at a rate set by the capacitor C3 and resistors R4 and VR1.

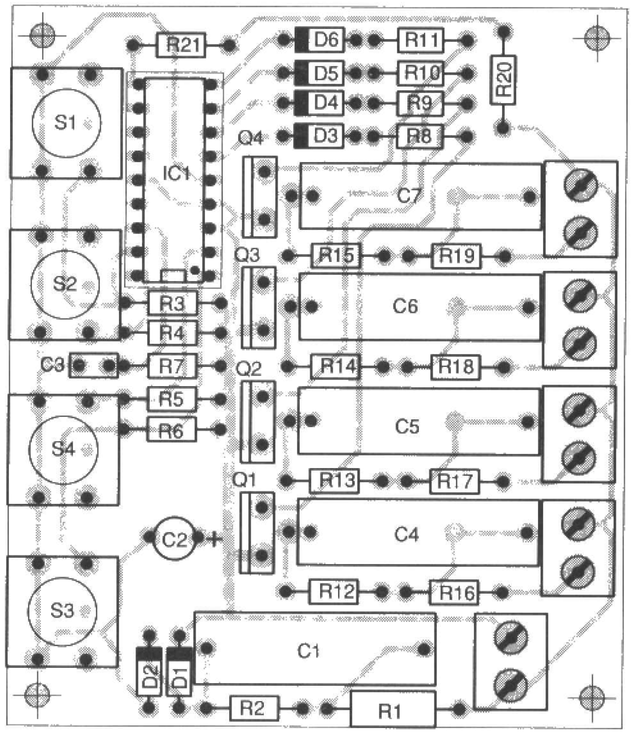
VR1 could be a preset or panel mounted component as required and connecting two triacs as shown would enable another LED chain to be flashed alternately. As a flashing display can become a bit irritating, a switch S1 has been incorporated to enable the display to be switched from flashing to continuous mode by continuously triggering the triac when flashing is not required.

Note that although a half wave circuit is shown here, a triac can switch on in both directions so that a full wave LED chain as shown in figure 2a could also be used. Triacs are not often damaged by high voltage spikes on the mains supply, as they simply turn on, but if there is sufficent energy in the transient then damage can occur. This is normally avoided by fitting a snubber network consisting of a capacitor and series resistor across the device. Unfortunately, this cannot be done here as any capacitor connected across the triac would pass sufficient current to enable the LEDs to light even when the triac was off and so to prevent damage due to mains transients a Voltage Dependant Resistor (VDR) which can absorb these may be fitted between the MT1 and MT2 terminals of the device. These comments also apply to the other circuits shown here.

Virtually all Christmas tree lights flash and so if something a bit more "up market" is required, some more sophisticated electronics will be needed. The use of a CMOS counter such as the 4017 for example can provide a moving light display as shown in figure 5 with the speed of the display being controlled by VR1. Here, each output of the counter goes high in turn (until output 4 goes high and resets the counter to 0) causing each triac and LED chain to be lit in turn. By staggering the chains as shown in figure 6, and twisting them together a chasing or moving effect can be produced as each group of LEDs is lit in turn. Instead of running four wires back to neutral, a single common wire could be used for all four chains. A low voltage power supply for the counter can be obtained from the mains by means of a dropper capacitor and zener diode circuit similar to that shown in figure 4.

If other patterns are required, such as flashing in pairs, etc.,

Figure 8: the component overlay for the Christmas tree light controller



diodes could be added to select which triac or triacs will turn on when a counter output goes high, but all displays of this type will of course only provide one pattern and using switches to select different patterns would soon become very complicated. Realistically, if more than one or two patterns are required, it is far better to program an eprom with all the lighting patterns required and simply switch the address lines to select the pattern required. In this case of course it is just as easy to program two patterns as twenty-two, and it is then simply a matter of selecting the required block of memory to display the required pattern.

The problem with using an eprom is that a clock generator and counter are still required to cycle through the addresses to generate each pattern in a sequence resulting in at least three ics and a few BCD switches to select a particular sequence, and if other features, for example the automatic selection of a new sequence after a certain time, are required, even four or five ics may not be enough. Since the cost of a microcontroller which contains an eprom is now less than that of most eprom chips, it makes sense to use one of these devices as no address counter or other logic will then be required and the sequences can be selected using only a single push button offering further savings in the cost of switches etc. Although not done in this circuit, even a 7-segment display showing the "sequence now playing" could be added for very little additional cost.

Planning for the future

The circuit shown in figure 7 will really bring your Christmas tree display into the 21st century and if carefully constructed it could serve your great-grandchildren well into the 22nd, assuming that Christmas trees have not by then been replaced by a holographic image projected into the corner of the room by lasers or something even more exotic.

The patterns are stored in the micro-controller eprom as a "look up" table and are read out at a rate determined by a software time delay routine and the mains frequency. This is basically a register which counts down from a previously loaded number to zero. The display rate can therefore be varied by changing the number which is initially loaded into the register. A larger number will take longer to decrement to zero and will therefore result in a slower speed while a smaller initial number will give a faster speed. The program has been arranged so that pressing either of the two push-to-make switches S1 and S2 will enable the speed to be set thus eliminating the need for the more usual potentiometer.

Switch S3 when pressed, will cause the next pattern stored to be displayed while S4 functions as a mode switch. When the circuit is first switched on, MODE 0 is selected which continuously flashes all outputs on and off and is the first pattern stored and this will be displayed indefinitely or until S3 is pressed to advance the display to the next pattern which causes the LED chains to flash in pairs. Pressing S3 repeatedly, enables any of the 8 display patterns stored to be selected for continuous display.

Pressing S4 will select MODE 1 which will display each pattern 32 times before automatically advancing to the next pattern. This will continue until the eighth pattern has been displayed when the first pattern will again be selected and the process repeated indefinitely. Pressing S4 repeatedly will select MODE 2, MODE 3, MODE 4, MODE 5 and MODE 6 in turn which will switch outputs 1, 2, 3, 4 or all on continuously. Thus by connecting all the red lamps to output 1, all green ones to output 2 and so on, the colour of the display can be changed from red to green etc. or all colours. Pressing S4 again will select MODE 0 again.

The use of a microcontroller means that the circuit is relatively simple. The mains input is fed to input port B4 by a simple resistive dropper consisting of R20 and R21 and this is used as the time base to determine the display speed. The internal input protection diodes on this input serve to clamp the input voltage to within 0.5 Volts of chip supply voltage thus preventing damage. The circuit operates from a nominal 4 Volt supply derived from the mains by capacitor C1 and associated

components R1, R2, D1, D2 and C2 while the triacs are driven directly by ports B0-B3 which are configured as outputs. Because triacs are more sensitive to negative trigger currents, the circuit operates from a negative supply and the outputs switch to -4 volts to trigger the devices. The trigger current is limited to around 5mA by resistors R8 to R11.

The mains droppers for the LED lamps have been included on the printed circuit board and are labelled C4 to C7 on the circuit diagram, but the reverse protection diodes or bridge rectifiers have to be mounted "off the board". All the other functions are controlled by the microcontroller which operates from an on chip clock oscillator running at a frequency determined by resistor R7 and capacitor C3.

Construction and testing

A suitable printed circuit layout for this circuit is shown in figure 8 and should be followed carefully. Note that mains voltages exist on the board during operation and the circuit should ALWAYS be switched off and disconnected from the supply before any adjustment or soldering is attempted. The circuit must not be earthed under any circumstances as serious damage to components will occur. The only components which need special mention are the "mains dropper" capacitors which must of course be rated for use on 240V ac supplies, and the triacs which should have a minimum rating of 400V and a maximum trigger current requirement of 5mA.

Normal precautions should be taken in handling the components, especially the microcontroller which is a CMOS device and therefore static sensitive. The use of a socket for this component is therefore strongly recommended. The completed circuit may be housed in a suitable plastic box with a lead terminated in a mains plug fitted with a 2A fuse. The LED strings need not be plugged into the box but may be permanently soldered into place and brought out of the box via a strain relief bush to prevent them being pulled from the circuit board.

Once construction is complete, check your work carefully. Remember that we are dealing here with mains voltages and an incorrect connection could easily result in the instant destruction of your circuit. Once you are satisfied that all is correct, and with the ic removed from its socket, plug the unit into the mains and carefully measure the voltage between pins 5 and 14 of the IC socket. A reading of about 4 volts dc should be obtained with pin 5 being negative. Note also that all LEDs should remain off. If all is well, disconnect the unit from the mains and depress one of the switches for a few seconds to discharge C2 and then plug the ic into its socket. Plug the unit into the mains and this time the outputs should flash. Press switches S3 and S4 and check that they function correctly. As all the functions are controlled by the program, no setting up is required.

Other applications

Finally, for those who do not relish the prospect of wiring up strings of LEDs, it should be realised that the circuit can also drive four sets of conventional tree lights or even ordinary mains lamps in applications such as discos or if your tree happens to be as large as the one in Trafalgar Square. In this case, the capacitors, resistors and diode associated with each LED string should be omitted and the lamps connected directly to the MT2 terminal on each triac. For LEDs or small Christmas Tree lights, no heatsinks on the triacs are required but if the load on each triac exceeds about 300W, heatsinks should be provided and the use of isolated tab triacs will simplify this considerably. Note that the TIC206D specified for this project do not have isolated tabs and will require insulating washers if a common heatsink is to be used.

One problem which is encountered especially when driving higher powered lamps (resistive loads) is the radio interference generated, and this normally requires the use of expensive and bulky chokes and capacitors to suppress. In case filament lamps are to be used in place of LEDs, a special routine has been programmed into the micro-controller memory to allow the triacs to switch on only during the mains zero crossing (Zero Voltage Switching), eliminating interference. This also has the added advantage of lowering the initial inrush current to the lamps when they are switched on which results in an extended lamp life.

The zero level switching leads to an interesting consequence when LEDs are used. Although, on the face of it, one might expect the phase shift caused by the capacitive current limiting to cause the triggering to occur at the mains peak, in fact, if the capacitors are discharged by their parallel resistors between flashes, then the zero level switching will be effective in reducing the inherently lower interference associated with lower current LED switching.

PARTS LIST for the Multicolour Light Chain

Resistors

R1	470R 1W
R2, R12-15	1M
R3-R7	10K
R8-R11, R16-R19	220R
R20, R21	2M2

Capacitors

C1	470nF/250V ac
C2	470uF/16V
C3	100pF
C4-C7	220nF 250V acg

Semiconductors

D1	BZX85C4V7 Zener diode
D2-6	1N4148 diode
Q1-Q4	TIC206D triac
IC1	PIC16C54-4L Pre-programmed Microcontroller

Miscellaneous

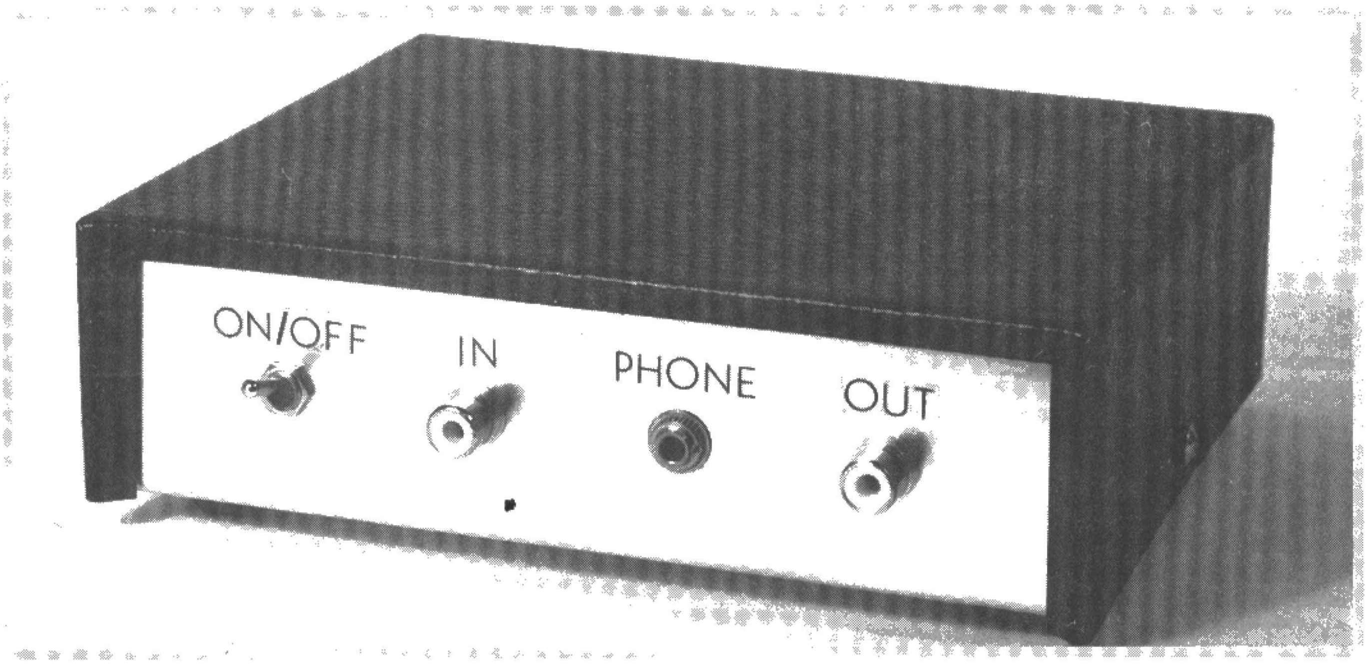
- S1S1-S4 Push to make switches, 5 x 2-way PCB mounting screw terminal blocks, printed circuit board, 18 pin DIL socket, plastic box with sufficient room for cooling.

The pre-programmed PIC16C54-4L Microcontroller is available from the author at £9.50 (including postage). Please send cheques or postal orders to: B. Trepak, 20 The Avenue, London W13 8PH. Mail Order only. Overseas orders must include payment in pounds Sterling with a banker's draft drawn on a British bank.

We will consider printing the program listing of approximately 270 lines for the 4-way XMAS tree lights controller in a future ETI if there is sufficient demand for a listing to be printed rather than obtained as a programmed PIC from the author.

Cable Break Locator

Why write off another cable? Robert Penfold's electronic cable tester helps to locate the break and recycle the cable.



Most cable testers are just continuity checkers, customised to make it easy to test a particular type of cable, or perhaps several different types of cable. A signal is coupled into each wire in the cable, and a check is made to determine whether or not each signal emerges at the other end. If a signal is absent, the corresponding wire is broken and the cable is faulty.

This type of tester is all right as far as it goes, but it has the drawback that it tells you if the cable is broken, but gives no idea as to whether it is worth trying to mend it, or any clue about the best way to set about mending it. With the majority of broken cables the problem is due to repeated flexing of the cable close to one of the plugs. This eventually results in one of the conductors breaking due to metal fatigue. This leaves the majority of the cable intact, and still useable.

To fix the cable it is only necessary to disconnect the plug, shorten the cable at the damaged end, and reconnect the plug. If the plug is a moulded-on type, it must be cut off with the damaged cable and replaced with a new plug. But sometimes the cable is damaged towards the middle, and it is then beyond rescue. Provided the plugs are not moulded-on types they can be removed and used on a new piece of cable, but there is little point in trying to reuse the cable itself.

Sniffing Around

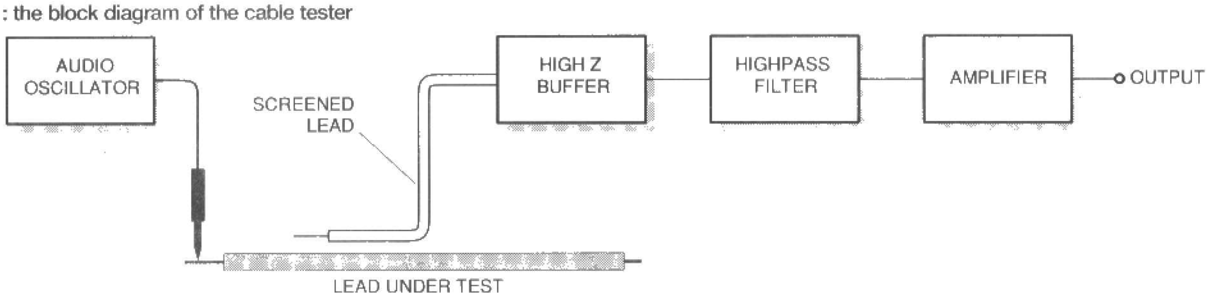
A cable tester would be more useful if it could indicate the position of the break. It is possible to produce a simple tester that will do this with many kinds of cable, but screened leads are not always amenable to this type of testing. The cable tester featured here is a form of break locator rather than a simple continuity style cable checker.

The block diagram of figure 1 helps to illustrate the way in which this cable tester operates. An audio oscillator generates a signal that is fed into one end of the wire. The rest of the unit consists of an audio "sniffer" which can detect the audio signal radiated by the cable without making any direct connection to it. The sensor is just a piece of screened lead with a short section of the outer sleeving and screening removed from one end. This gives a small amount of capacitance between the end of the sensor cable and the cable under test, but provided the two are close together this is sufficient to couple a small amount of the audio tone signal into the sensor.

The impedance from the test cable to the sensor is very high at the operating frequency of the oscillator, which is a little over 1kHz. An extremely high input impedance is needed in order to obtain an adequate coupling into the "sniffer" circuit. A high impedance buffer stage is therefore used at the input of the circuit, providing an input impedance of 10 megohms.

The high sensitivity of the circuit leaves it vulnerable to strong

Figure1: the block diagram of the cable tester



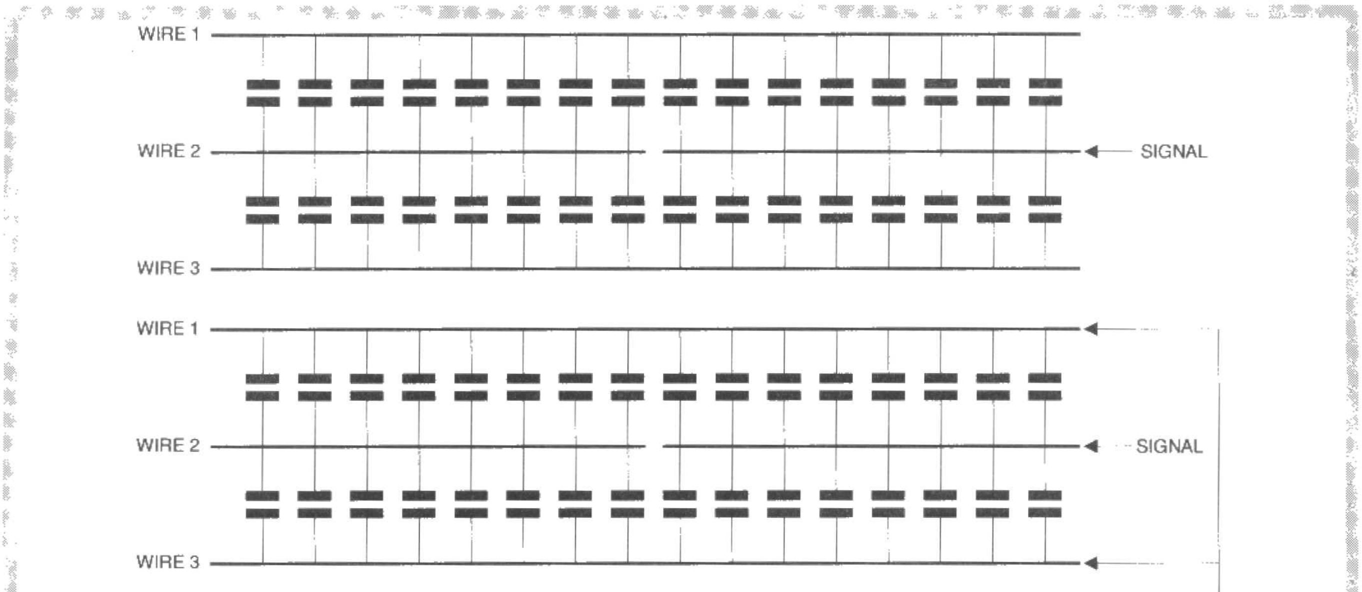


Figure 2: capacitance in a multi-way cable bypasses the break in the wire (top). Earthing the other wires avoids this (bottom).

pickup of 50Hz mains hum. This would probably not be severe enough to prevent the unit from working, but it could make it difficult to use. A lowpass filter is therefore used to attenuate signals below 1kHz, and this gives over 80dB of attenuation at 50Hz. An amplifier stage boosts the sensitivity of the circuit to a level that gives good results with a crystal earphone (marked "phone" in the photographs).

In use the tip of the sensor lead is run along the cable, starting at the end where the audio signal is injected. Initially a strong audio signal should be obtained, but at some point the signal will be lost. This point is usually well defined, and it indicates the position of the break in the wire.

Bypassing

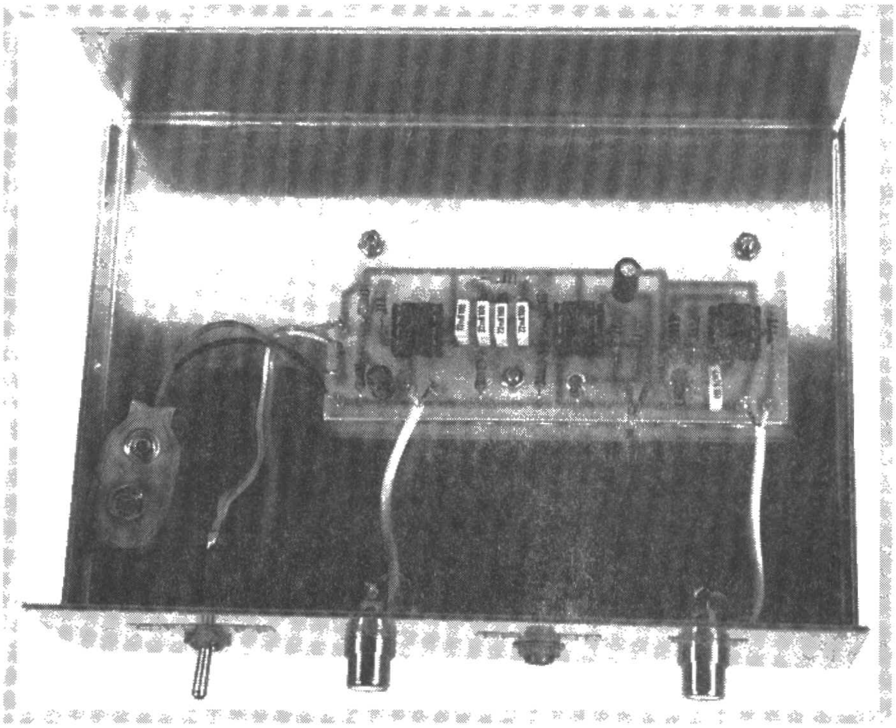
In practice there is usually a problem with this basic method of testing, due to the fact that most cables have two or more wires. Capacitance between the wires in the cable tends to "hide" the break. The upper diagram in figure 2 helps to explain the problem. The cable has three wires, with a break in the middle wire ("Wire 2"). There is capacitance from this wire to the other two along the full length of the cable. This is analogous to having numerous tiny capacitors connected between the wires at intervals along the cable.

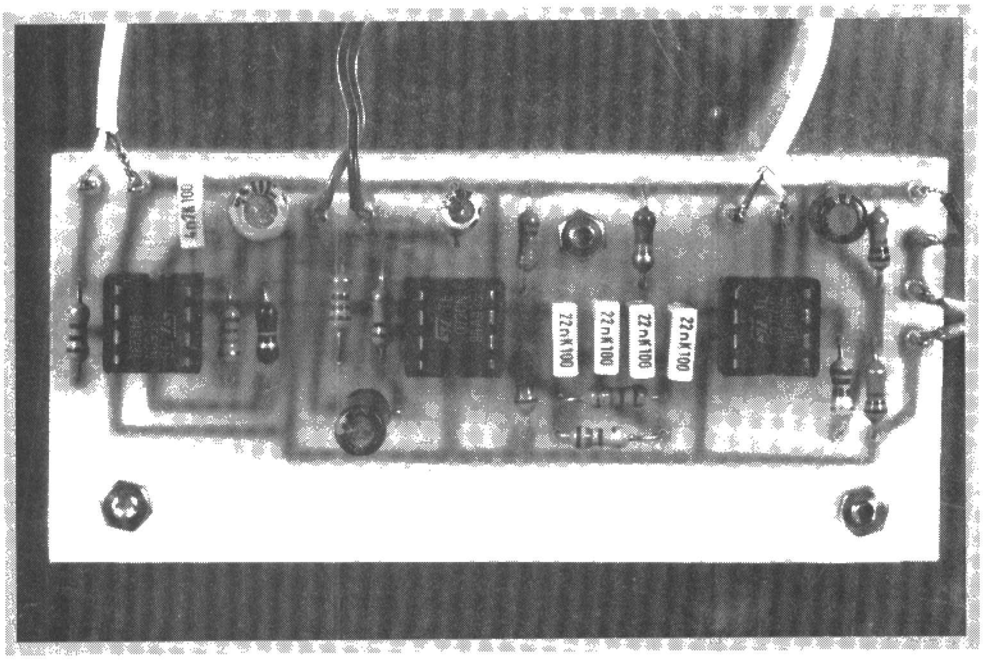
If a signal is injected at one end of "Wire 2", it is coupled around the break in this wire by the capacitance in the cable. The coupling to the far section of the cable is weak, but it has to be remembered that the coupling to the sensor lead is via a minute amount of capacitance. The capacitance between the wires in the lead will be far higher than the capacitance from the broken wire to the sensor lead. In practice there will be a small drop in the signal level as the sensor is taken past the break in the wire, but it is likely to be so small as to be barely discernible.

Fortunately, there is an easy solution to this problem, which is to earth all the leads in the cable apart from the one that is being tested, as shown in the lower illustration of figure 2. This cuts off the coupling to the far end of the broken wire, and also prevents the other wires from coupling the test signal into the sensor lead. This gives a clear drop in the level of the audio tone as the sensor is taken past the break - as well defined as when testing a cable which contains a single wire.

Unfortunately, screened cables are more difficult to deal with than ribbon cables and other multi-way non-screened types. There is no difficulty in testing the outer conductor using the standard technique, but it is difficult to test the inner conductor (or conductors). The problem is simply that the screen is designed to prevent signals from getting in or out of the cable, and this it does very well. This makes it impractical to test the inner conductor using the standard technique.

Nevertheless, this tester can still be used to locate damage in some screened cables. Even if the break in continuity is through one or more of the inner conductors, the outer braiding often suffers some damage as well. This lets some of the signal from the inner conductor leak through to the outside world. Screened cables can therefore be tested by coupling the audio signal into the inner





IC3b is used in the output amplifier, and this is a non-inverting circuit having its voltage gain set at just under 50 (34dB) by R12 and R13. C9 couples the output signal to the earphone socket, but it is not strictly necessary if the unit is used with a crystal earphone. It is mainly included as a safety measure to protect IC3b if a low impedance earphone is connected to SK3. The unit is unlikely to provide worthwhile results if used with a low impedance earphone, since these have very low sensitivities. It will work reasonably well with most medium impedance (personal stereo type) headphones if the two phones are wired in series. The sensitivity might be a bit high, but this can be corrected by reducing R12 to a value of about 15k.

The current consumption of the circuit is only about five milliamps or so. A PP3 size nine volt battery is therefore adequate to power the unit, even if it is likely to receive a great deal of use.

conductors, and then "sniffing" along the length of the cable in search of some "leaked" audio tone. This method can not be guaranteed to work in every case, but it often seems to "deliver the goods."

The Circuit

The circuit diagram for the cable tester appears in figure 3. The audio oscillator is based on IC1, which is a low power 555 timer used in the standard astable mode. The specified timing component values give a virtually squarewave output at a typical frequency of 1.1kHz. R3 is a protection resistor which is connected in series with the output signal. It is likely that accidental short circuits will occur at the output from time to time, and R3 limits the output short-circuit current to a safe level. Its value is too low to have any significant effect in normal use.

IC2 is used as the basis of the buffer amplifier at the input of the "sniffer" circuit. This is a simple non-inverting buffer stage having its input impedance set at 10 megohms by input bias resistor R6. The buffer stage feeds into a conventional fourth order (24dB per octave) high pass filter based on IC3a. The filter's cutoff frequency is approximately 1kHz, so it gives no significant attenuation at the frequency of the test tone. It gives massive attenuation at the problem frequency of 50, but mains hum contains harmonics at higher frequencies (100Hz, 150Hz, etc.). Consequently, the output signal from the "sniffer" circuit might not be completely free from mains hum, but any mains-borne interference should be at a very low level.

Construction

Refer to figure 4 for the component layout. None of the ics are static sensitive, but I would still urge the use of holders. Note that IC1 is correctly shown as having the opposite orientation to the other two devices.

The capacitors must be the correct types or it will be difficult to fit them into this layout, if they can be used at all. The electrolytic capacitors must be miniature radial type. Be careful to fit them with the correct polarity. The polyester capacitors must be miniature printed circuit mounting types with a lead spacing of 5 mm or 0.2 inches.

Once all the components have been fitted, complete the board by adding single-sided solder pins to the remaining connection points. Tin the tops of the pins with plenty of solder, and it should then be easy to make connections to them.

A metal instrument case measuring about 152 by 114 by 44 millimetres was used as the housing for the prototype, but this is substantially larger than strictly necessary. A metal case is preferable to plastic, since it provides screening of the sensitive "sniffer" circuitry, and helps to minimise pickup of mains hum and other electrical interference.

A small amount of breakthrough from the oscillator to the "sniffer" circuit is inevitable, but a good front panel layout will help to

Figure 3: the full circuit of the cable tester

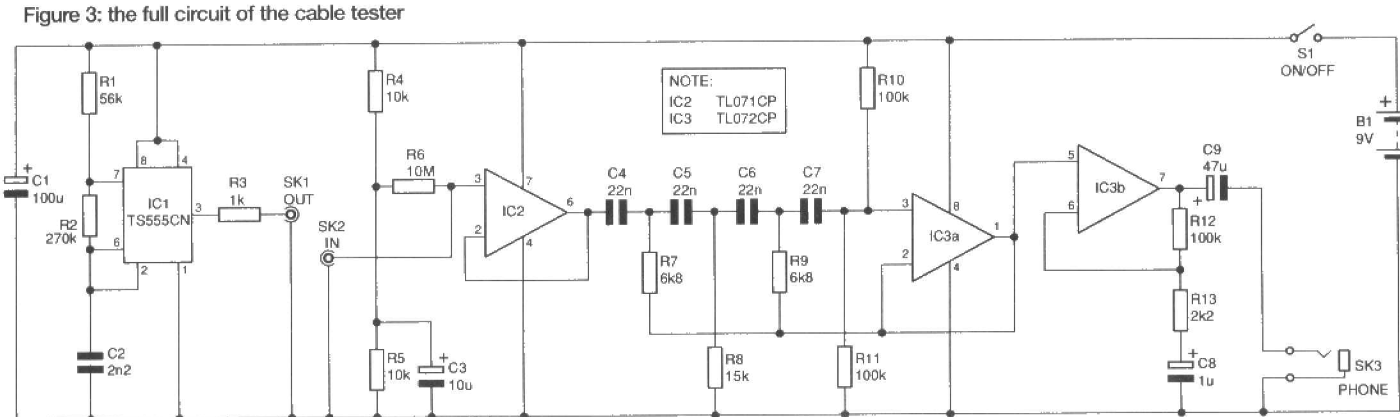
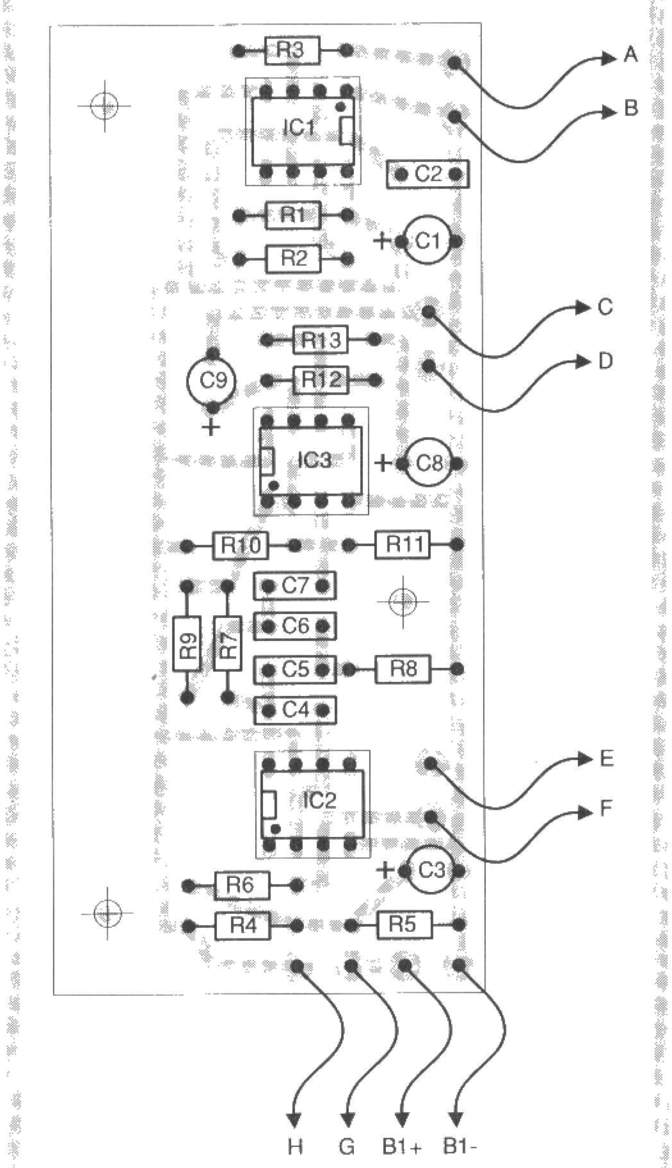


Figure 4: the component overlay for the PCB



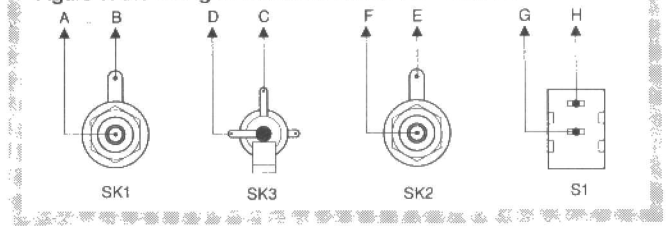
keep it to a minimum. Choose a layout that keeps SK1 and SK2 reasonably well separated, and avoids crossed- over wires. Use an overall layout the enables the wiring from the front panel components to the printed circuit board to be kept reasonably short.

See figure 5 for details of the point-to-point wiring. Point "A" in figure 4 connects to point "A" in figure 5, and so on. The lead which connects SK2 to the board must be a screened type, or there will certainly be excessive stray pickup of the oscillator signal. Using a screened lead from SK1 to the board is not essential, but helps to minimise oscillator breakthrough.

Two test leads are needed in order to use the tester. The sensor lead connects to SK2, and it consists of about 0.5 metres or so of good quality screened audio cable. A phono plug is fitted to the lead at one end, and about 10 mm of the outer sheath and screen are removed from the other end to produce the sensor.

The oscillator test lead consists of a phono plug with about 0.5 metres of multi-strand connecting wire fitted to the centre (non-earth) tag. The other end of the lead is fitted with a miniature crocodile clip or a probe clip so that it can be easily connected to the lead under test. The earth tag of the plug should be connected to at least two leads and clips, so that the wires in a multi-way cable that are not being tested can be earthed to the chassis of the tester.

Figure 5: the wiring to the on/off switch and sockets



In use

When the unit is switched on there should be a small amount of background hiss from the earphone, plus a quiet audio tone which is the breakthrough from the oscillator. If the noise and (or) audio tone are absent, switch off immediately and recheck the wiring, etc. Assuming all is well, place the "hot" end of the sensor lead close to the non-earth output lead connected to SK1. The tone should become much louder when the sensor is placed near the lead carrying the oscillator signal.

It is then just a matter of applying the test techniques described in this article. With multi-way leads remember to earth any wires other than the one being tested. Inject the oscillator signal into the inner conductor or conductors when testing screened leads. Then earth the screen and check for signal "leaks" using the sensor. It is a good idea to deliberately damage a few scrap pieces of lead so that you can get some practice before trying the "real thing." When testing "real world" leads it is generally easier to connect the unit to the leads via the appropriate types of socket, rather than trying to make connections direct to the pins of the plugs fitted to the leads. The sockets usually have reasonably large and well separated tags to which the test clips can be attached without too much difficulty. Making connections direct to the plugs is usually very tricky, especially with most DIN types.

PARTS LIST for the Cable Tester

Resistors (all 0.25 watt 5% carbon film)

R1	56k
R2	270k
R3	1k
R4,R5	10k (2 off)
R6	10M
R7,R9	6k8
R8	15k
R10,R11,R12	100k (3 off)
R13	2k2

Capacitors

C1	100u 10V radial elect
C2	2n2 polyester
C3	10u 25V radial elect
C4,C5,C6,C7	22n polyester (4 off)
C8	1u 50V radial elect
C9	47u 25V radial elect

Semiconductors

IC1	TS555CN
IC2	TLO71CP
IC3	TLO72CP

Miscellaneous

S1	SPST min toggle switch
SK1,SK2	Phono socket (2 off)
SK3	3.5mm jack socket
B1	9 volt (PP3 size)

Small metal instrument case, printed circuit board, battery connector, 8-pin DIL holder (3 off), crystal earphone with 3.5mm jack plug, test leads (see text), wire, solder, etc.

Giant Musical Bargraph

Now you can have 100 LEDs to play along with your 76 trombones. Paul Brow's bargraph display is bigger than some people's hifi - and comes in two sizes.

Many of us can remember the old needle type VU meters, prolific on hifi tape decks and some amplifiers in the 1970s. They virtually disappeared because of the high cost and the introduction of solid state LED bar graph displays. Being fascinated with the new technology, I modified an amplifier in 1977, fitting two 10-bar LED displays as power meters. As bar graph ics were not available, the 10-driver channels were made from three quad op amps and a reference ladder of resistors - a high component count for a simple display. Today, all modern tape decks, mini hifi units, equalisers and some amplifiers are fitted with a variety of bar graph displays using custom drivers ics, and displays such as LED, LCD, and fluorescent. The displays are configured most commonly as stacked bars or blocks, and all perform the same basic function of showing signal level, overall or at particular frequencies. We have also all

Figure 1: the circuit of the audio input, AGC and inverter and inverting buffer

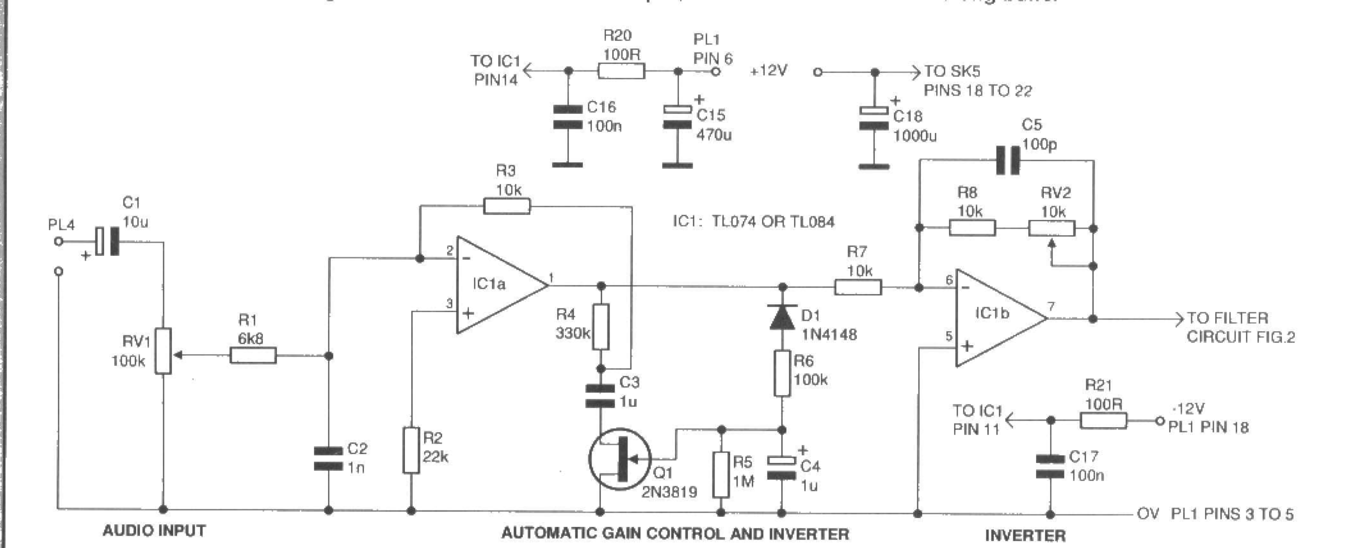


Figure 2: the circuit of the low pass filter, high pass filter and diode pump

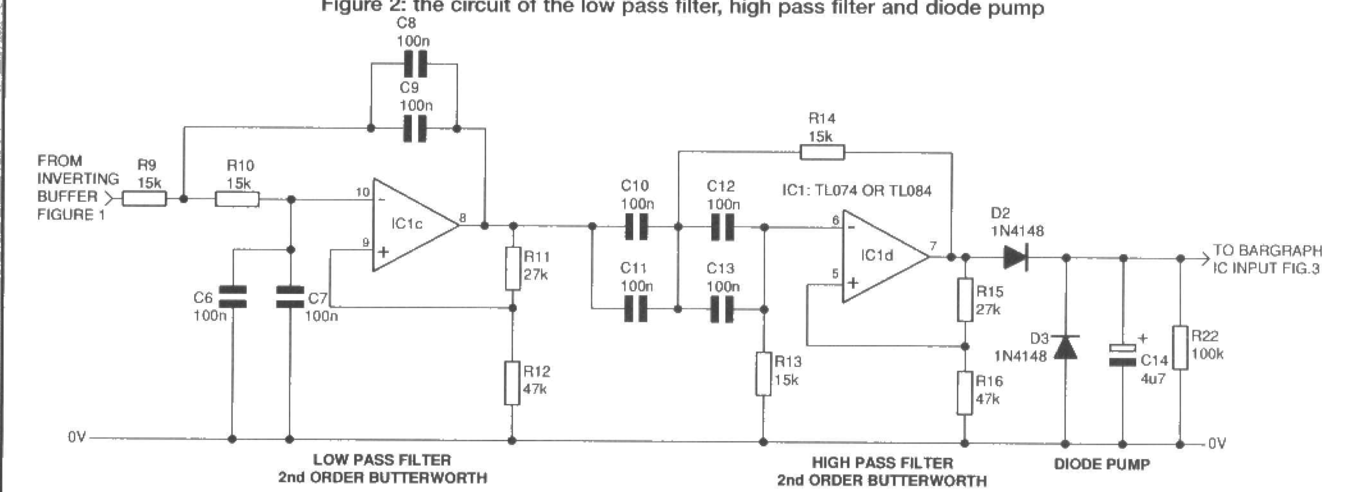


Figure 3: the circuit of the bargraph driver - basic 20mA per output version

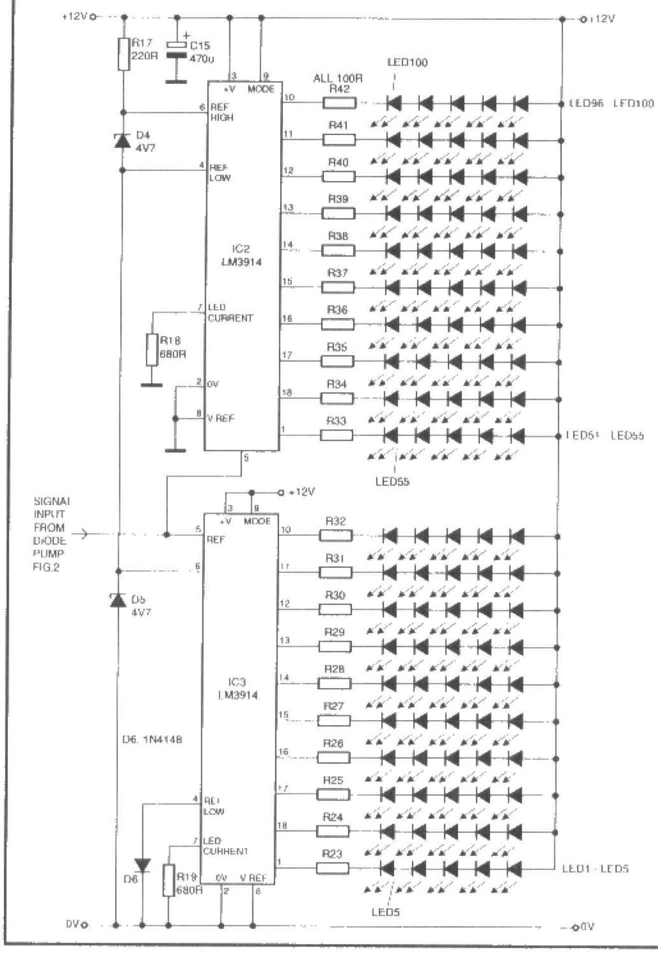


Figure 4: capacitor values for alternative frequencies

Frequency	Cx	C6, C8, C10, C12	C7, C9, C11, C13
50Hz	212n	100n	100n
100Hz	106n	100n	–
200Hz	53n	47n	4n7
500Hz	21n	22n	–
1kHz	10n	10n	–
2kHz	5n3	4n7	470p
4kHz	2n6	2n2	470p
8kHz	1n3	1n	330p
16kHz	660p	560p	100p

$$C = \frac{1}{2\pi Rf}$$

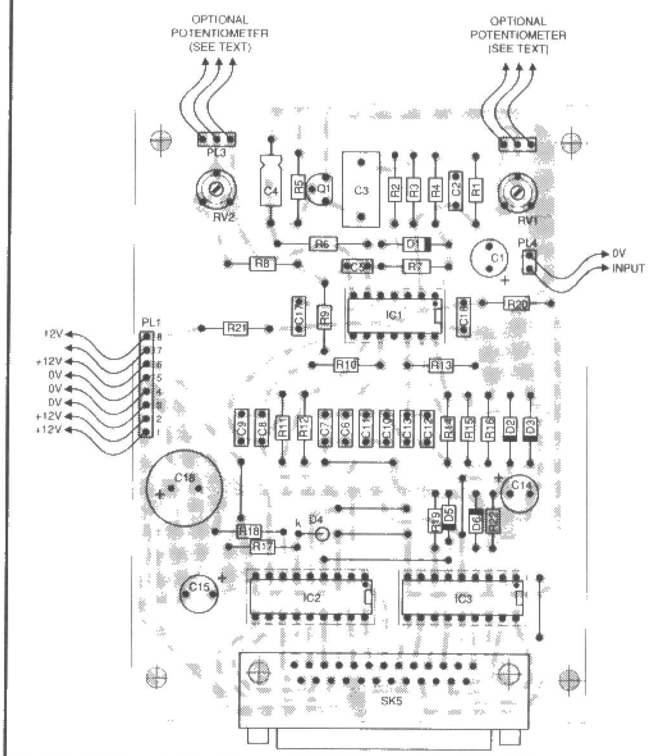
$$C\,(\text{nF}) = \frac{1{,}000{,}000}{6.28 \times 15 \times f}$$

seen sound to light units, so I wondered how effective a combination of these would be - hence this project, a giant sound-to-light driven LED bargraph.

Modern audio equipment uses anything from five simple LEDs to ten or twenty individual segments. The display is large and I didn't want the discrete steps to be noticeable so I decided that 20 separate bars of 5 giant 10mm LEDs would be effective. More on the display design later.

I have designed the control circuit, figures 1 to 3, to give the most pleasing and effective display. Music content can vary wildly, so displaying different types would require some control adjustment. Enter automatic gain control (AGC), which produces a fully effective display with loud or quiet music. This means, of course, that the display is no good as a true VU meter, as the combination of automatic gain control and linear display driver ics makes the actual levels meaningless.

Figure 5: the component layout of the 20mA version



Remember, this has been designed to be the most effective and entertaining display. I tried LOG and LOG/LIN display driver ics, but they were not effective visually. However, if you are curious (and have some expensive LOG driver ics lying around), try changing the LM3914 driver ics for LM3915, or even an LM3916, and check the result for yourself.

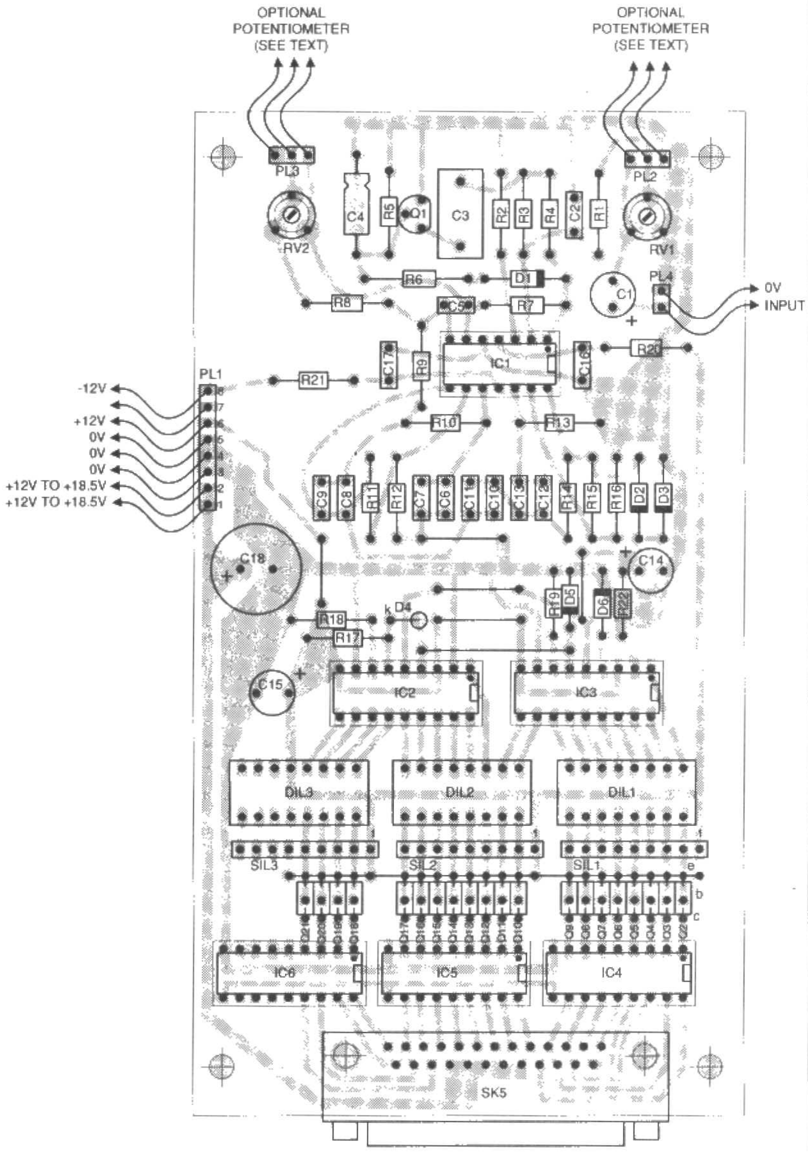
My preferred frequency range for display purposes is bass between 50 and 100Hz. However, this may not be everyone's choice so the control circuit is designed with active filters that can be configured for any frequency in the audio spectrum. This also means it is feasible for adventurous types to build a giant spectrum analyser display with seven to ten bar graph units - but we are getting carried away. Even so, figure 4 shows component values required for different frequencies.

Two versions

The circuit diagram shows two capacitors paralleled in each of the four filter capacitor locations, C6 to C13. Two capacitors can be combined to create the required value for a specific filter frequency. For 50Hz, an overall value of about 212nF is required so you could fit a 220nF capacitor in location C6 and forget about C7. Alternatively, you can fit a 100nF capacitor in location C6 and another in C7 to produce a total of 200nF, close enough for this purpose. The same applies to C8 through C13. Figure 4 shows some typical frequencies, and the overall value of capacitance that would need to result from each pair of filter capacitors. Figure 4 also gives the formula for calculating the overall filter capacitance for any frequency. The most common frequency arrangement for multiple displays like spectrum analysers is one bar for each octave. Alternatively, you could select frequencies that display bass, middle, and treble for a triple bargraph display. I leave this to the constructor's preference (and pocket depth), but you can choose various options.

I have included details of two slightly different board versions. The basic unit has a lower current drive capability,

Figure 6: the component layout of the high current version



perfectly adequate for LEDs but not for lamps or for multiple LED displays. The high current version includes transistor drivers that are rated at 500mA maximum per channel (as long as they have a suitably hefty power supply) for driving filament lamps or other custom displays of your own design.

The main project concentrates on the 20mA per channel version, driving 100 large LEDs. The parts list shows the additional parts required for the high current version. PCB layouts have been included for both versions.

The circuit

IC1 performs the automatic gain control and filtering. The audio signal, taken from the record output socket on an amplifier, for example, is input through DC blocking capacitor C1 to potential divider VR1. This allows input level matching, which is then normally left alone. C2 is a simple first order high frequency filter to eliminate possible interference. IC1a combined with Q1 forms an automatic gain control whose output is maintained at 1.5V to 2.8V over a much wider range of input signal levels, typically 10mV to 500mV. C3 and C4 set the auto gain time constant such that it still responds to the changes in the audio while being able to amplify small signals dramatically.

Effectively Q1 behaves like a voltage controlled resistor in the op amp negative feedback loop. The FET's resistance is low (high gain) for small audio signals and its resistance is high (low gain) for large audio signal levels. The auto gain amplifier output then, via R7, drives an inverting buffer amplifier formed by IC1b. The buffer has variable gain for set-up purposes but only from unity gain to times two. The gain can increased if necessary by making VR2 47K or even 100K. C5 is a simple high frequency filter to limit high frequency interference. The inverting buffer then drives the active filters.

IC1c forms a second order Butterworth response low pass filter and IC1d forms a complementary high pass filter at the same frequency which overall forms a narrow band pass filter, with a response curve as shown in figure 14. The default values for C6 to C13 of 100nF create a 50Hz narrow band pass filter with steep roll offs either side of 12dB per octave. R11 and R12 set the filter gain (similarly R15 and R16), hence the Butterworth response. After all the frequencies except those around 50Hz have been rejected, the resulting signal is rectified and converted into a pulsating DC level formed by the diode pump arrangement of D2, D3, C14 and R22. C14 and R22 set the display decay time constant, that is, they increase the value of C14 for a slower decay.

The diode pump then drives the two linear bar graph ics. These are cascade arranged such that IC3 forms the lowest ten bar segments and IC2 forms the upper ten segments. The zener diodes D4 and D5 form voltage references for the IC internal resistor divider chains, where the junction of D4/D5 is the HI reference for IC3 and also the LO reference for IC2. This creates a seamless transition where the signal level crosses from one driver ic to the other. The LO reference of IC3 is set slightly above 0V at 0.6V with D6 to prevent the bar graph

Figure 7: side view of the PCB build

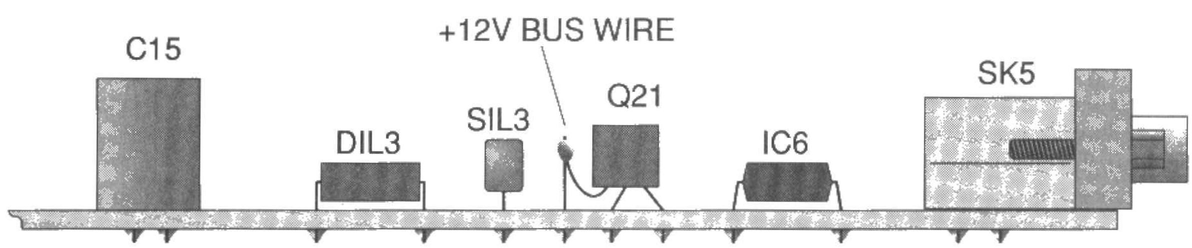


Figure 8: dimensions for the case cut-out for the D connector

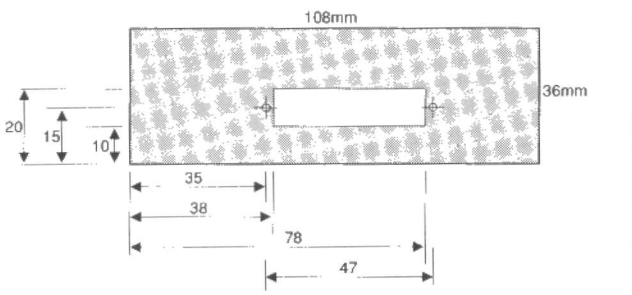
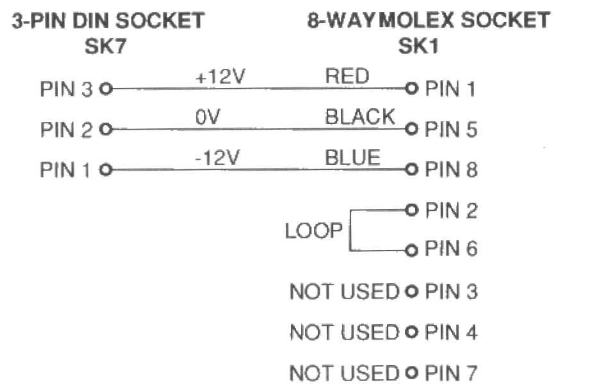


Figure 9: cable wiring chart



responding to system noise such as hiss or rumble. Both ics respond to about 4.4V making a total of about 8.8V required from the diode pump to illuminate all LED segments. R18 and R19 set the drive current maximum to about 20mA per output and R17 provides the bias current for the zener diodes. Current limit resistors R23 to R42 are not strictly necessary but provide protection in fault conditions, incorrect wiring or during testing.

In the high current version, the bar graph drivers IC2 and IC3 drive Darlington transistor arrays. SIL and DIL resistor packs are used to simplify the design (see figure 15). Q2 to Q21 convert the negative going signal to positive going to drive the transistor arrays IC4 and IC5. These are then capable of driving more LEDs or filament lamps.

Construction

The low current version is cheaper to build. Experimenters should build the high current version just in case. The main board is very straightforward. Insert all the physically smaller components first: wire links, resistors, ic sockets, SIL resistors, transistors, and then all the odd shaped components like capacitors, potentiometers and connectors. Fit the 25-way D connector last, but make sure that your PCB is trimmed such that the edge does not protrude beyond the edge of the D connector, as the connector barrel needs to stick out of the plastic case.

The 3 way Molex pin connectors and pre-set potentiometers are designed to be mutually exclusive. Fit the pre-set potentiometers VR1 and VR2 and omit the 3 way Molex pins if on board adjustment is required. Fit the 3 way Molex pins, omit the pre-set potentiometers and connect standard potentiometers to the Molex connectors if external adjustment is required. As regular adjustment is not required, I drilled two 4mm holes in the case top to gain access to the pre-set potentiometers for occasional adjustment.

Note the ZTX500s!

The majority of the additional components for the high current version fit according to the component overlay but the ZTX500 transistors Q2 to Q21 warrant a special mention. The ZTX500 was chosen because its physical size makes it easy to stack in a line to suit the spacing of the driver ics. This would have been perfect if the transistor pin out had been Base Emitter Collector to suit the way it

Figure 10: LED display component layout. FIVE identical modules as shown are required - increase the part numbers for four more PCBs.

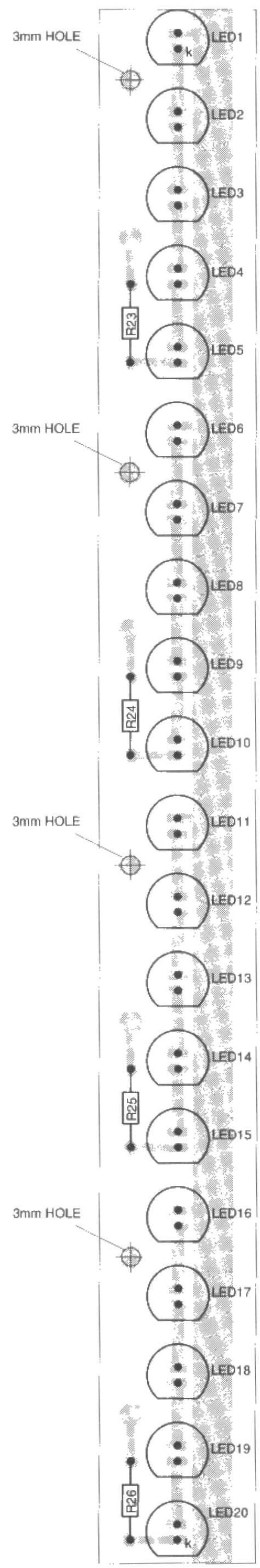


Figure 11: the display PCB spacer fitting

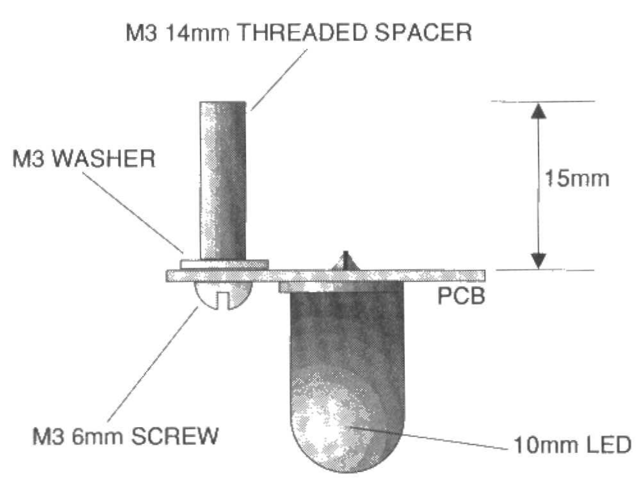
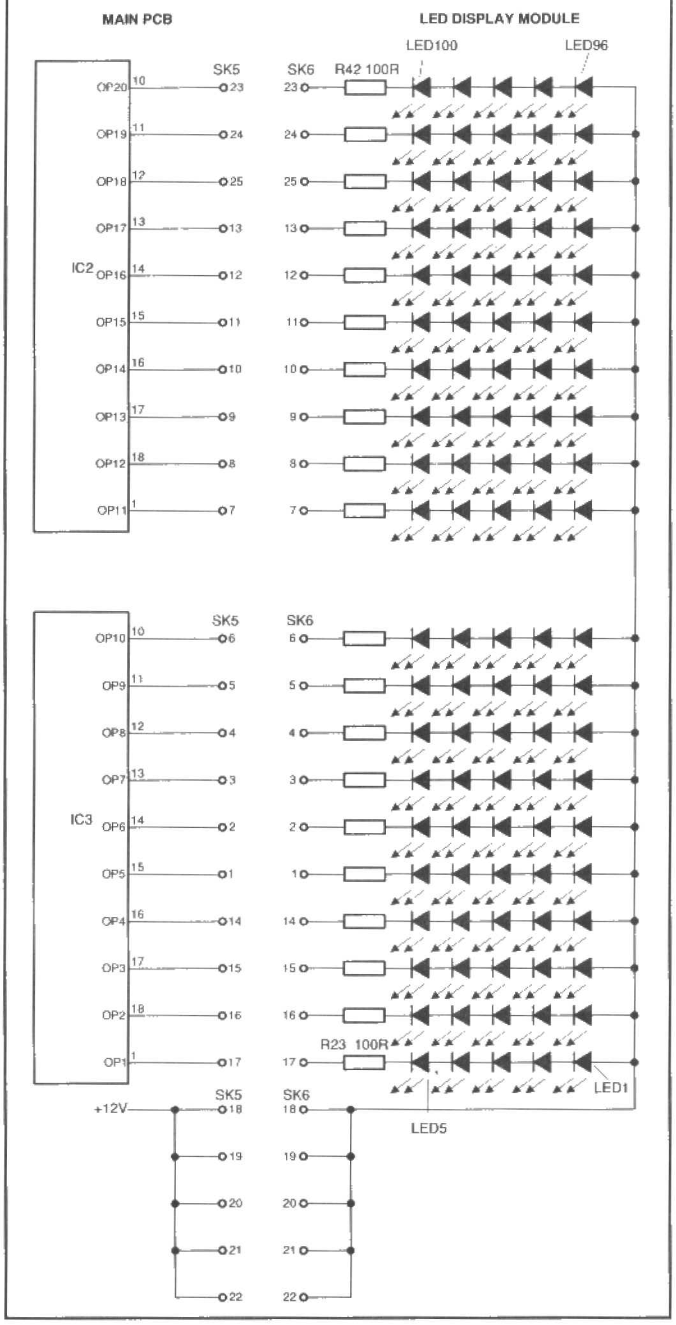


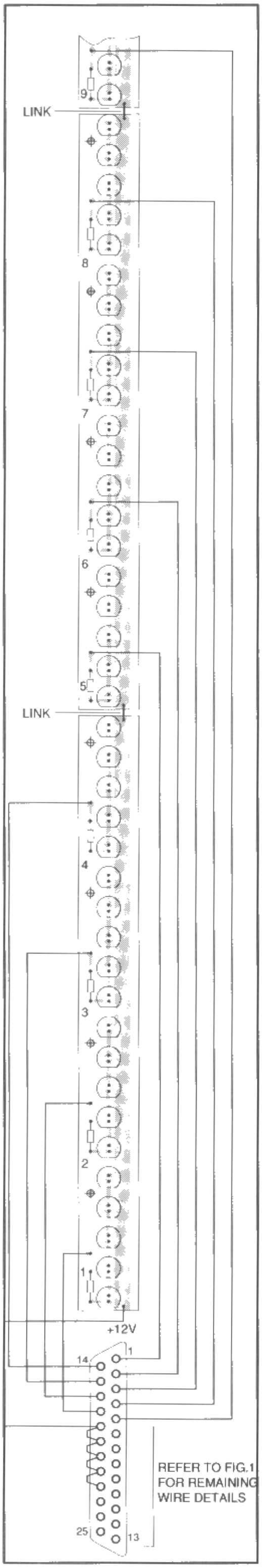
Figure 12: the output socket pin configuration



is connected but I could not find a commonly available transistor with the package style and pin out. The ZTX500 is Emitter Base Collector causing component layout problems. This was overcome by not fitting the Emitter leg through the PCB but connecting it to a bus wire on the component side instead. This keeps the layout design compact. The bus wire is really a long wire link with two support wires in the middle. See the component overlay, figure 6 and component side view, figure 7.

The Maplin case specified will fit both versions, and is easy to drill and file. The main difficulty is determining the exact position for the D connector cutout (see figure 8). When the cutout has been formed, attach the plastic end to the D connector - you will have to countersink the mounting holes slightly so that the UNC spacers do not protrude too far. Test fit this and the PCB to the case lower half and mark through the PCB holes. Drill and fit M3 12mm CSK screws with double nuts to act as 4mm PCB spacers. The other case end cap needs a 3 pin DIN socket (SK7) and a single chassis mount

Figure 13: the LED display wiring (part only shown) - connect wiring on copper side



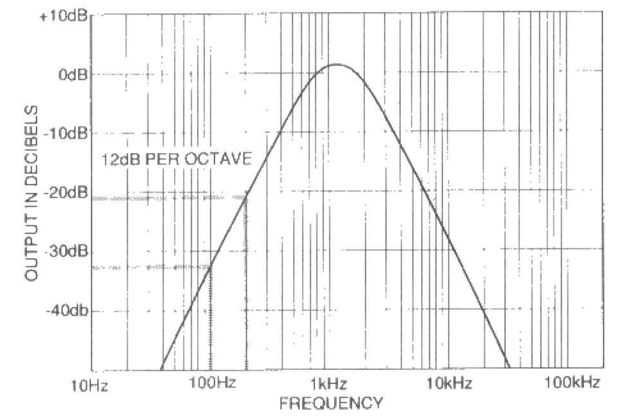
phono socket (SK8) mounting but positioning is not critical. Wire the 3 pin DIN socket SK7 to the 8 way Molex socket as shown in figure 9. Wire the phono socket with about 160mm of screened wire to a 2 way Molex socket (SK4). Make sure the cable screen connects to PL4 0V pin as shown on the component overlay in figure 5 or figure 6.

The construction of the bar graph display requires some accurate drilling but is more or less straight forward. Obtain a length of white electrical plastic trunking 38mm by 24mm by 1.5m. Remove the trunking top and place to one side - this will actually be used as the bottom of the display. Mark 100 hole positions all exactly 0.5 inch apart, centrally along the length of the trunking U section. Start approximately 120mm from one end. Sorry about the mixed measurement units, but the LED spacing is determined by the PCB imperial design grid. Carefully drill 100 holes of 10mm diameter. I used a bench mounted sheet metal punch, giving excellent results but slow drilling and careful de-burring is perfectly acceptable. At one end of the trunking make a cut out to accept a 25 way chassis mounting D connector. The trunking is now ready to accept the five identical display PCBs.

Display PCB construction

It is extremely difficult to etch a PCB 1.2 metres long! So the display is actually made up of five separate PCBs. Although the component numbers are listed as though it is one giant board, the five boards are all identically assembled and the resistors are all the same value. Insert R23 to R42 and then fit the 100 LEDs flat to the board.

Figure 14: filter response at 1 kHz



The board of the 20mA version of the Bargraph

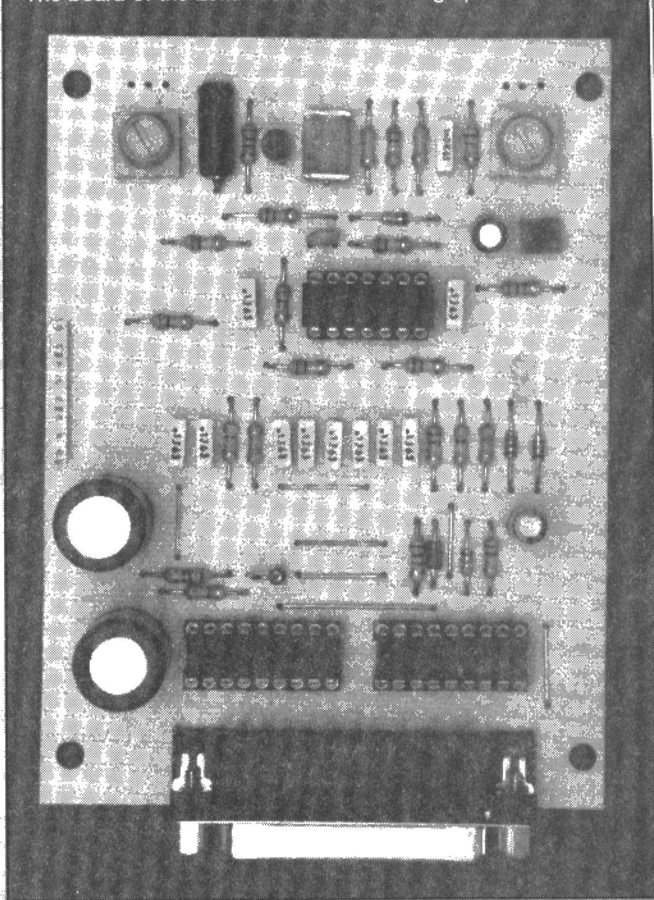


Figure 15: alternative high current driver circuit (see text) - example of one 500mA output

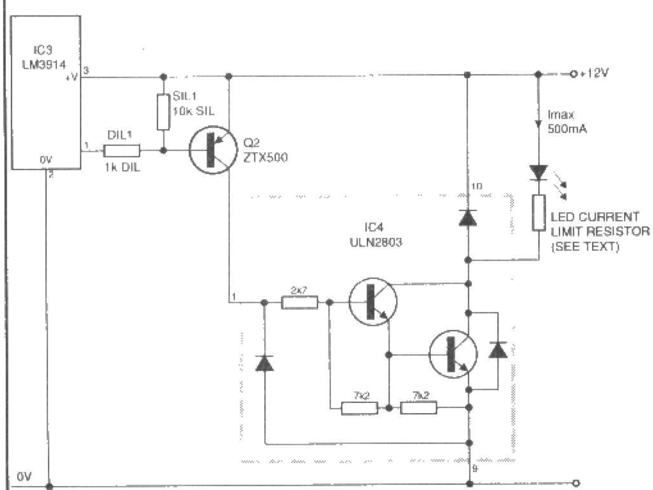
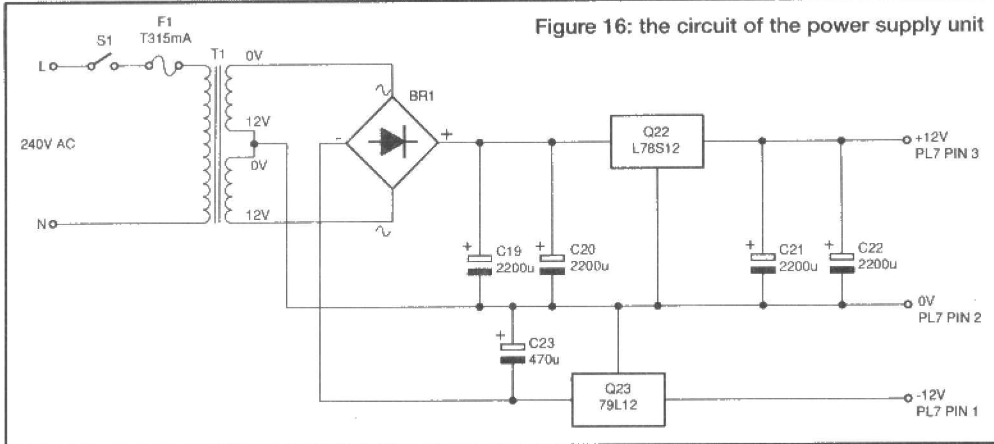
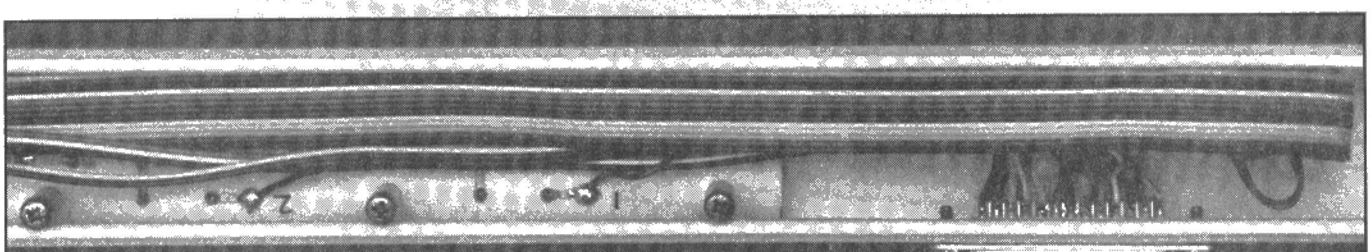


Figure 16: the circuit of the power supply unit



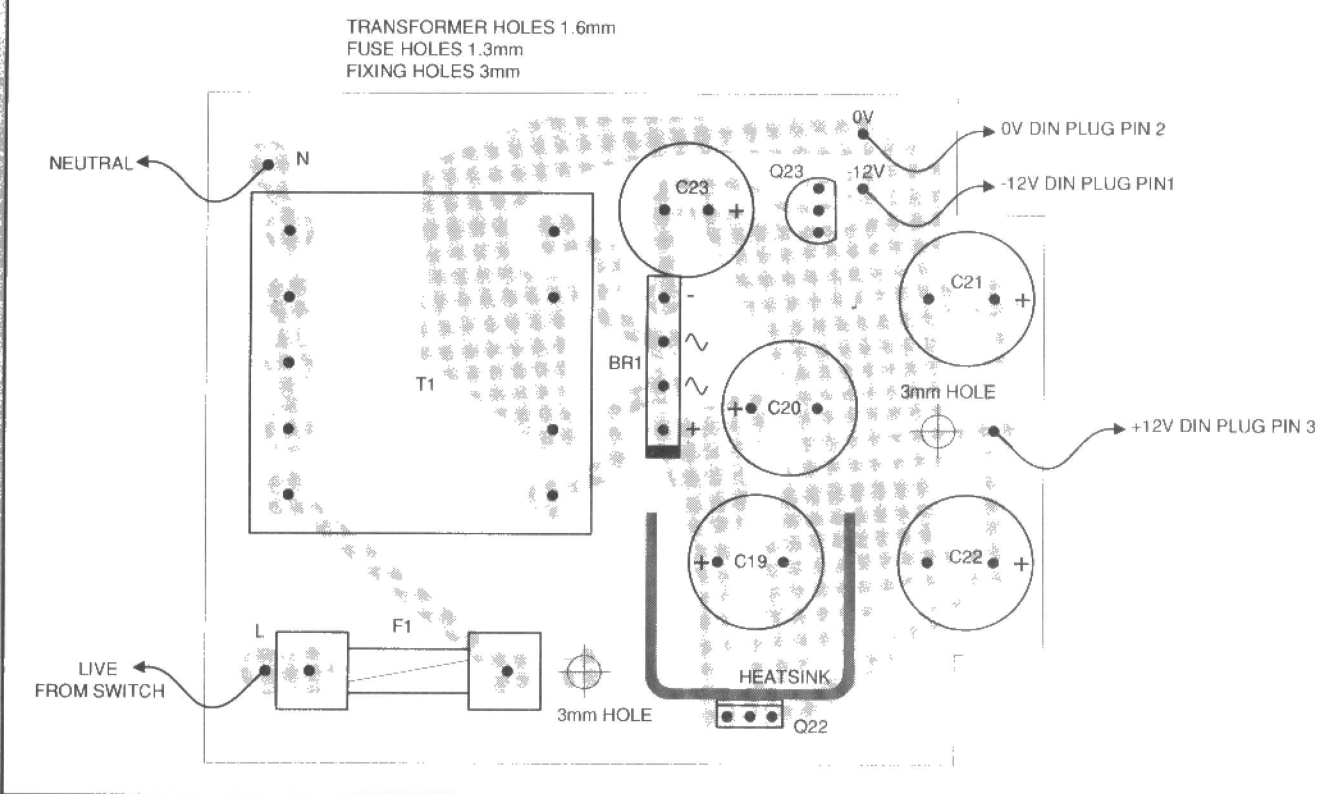
Ensure that the cathode leads all face the same direction as shown in figure 10. A 15mm spacer must then be fitted on the copper track side into the four holes per board - the spacer rests against the trunking lid (now display back) to prevent the LEDs being pushed inside the trunking. The 15mm spacers can be formed by using Maplin 14mm M3 threaded spacers and adding two or three washers (figure 11). Maplin sell insulated spacers with brass inserts of exactly 15mm but they are much more expensive (25p each) than the 11p 4mm type.

Insert the assembled display PCBs into the drilled trunking and then solder an 18 SWG tinned copper wire link from one board to another onto the wide +12V track (see photograph). Fit the 25 way D connector and then hard wire each pin connection to the



Part of the wiring of the five bargraph Light Unit boards, showing connector

Figure 17: the power supply component layout



display PCBs according to figure 12 and figure 13. I used rainbow ribbon cable to keep the wiring together. Carefully enclose all the wires and clip the 'lid' onto the trunking. You can test each segment by temporarily connecting a 12V supply, +12V to the pin 20 of SK6 and then touch the 0V supply to the appropriate D connector pin to illuminate a segment.

R23 to R42 are fitted as current limit protection so do not apply a supply voltage directly to the LEDs as this will destroy them.

Set-up and testing

If everything has been inserted into the main PCB the correct way round, of the correct value, and your soldering is of reasonable quality, then it should work first time. Connect the bargraph display to the main board using a 25-way fully connected male to male D connector lead. Make sure the lead is the type where pin 1 connects to pin 1, and similarly for all the remaining pins. It is less hassle (and cheaper) to

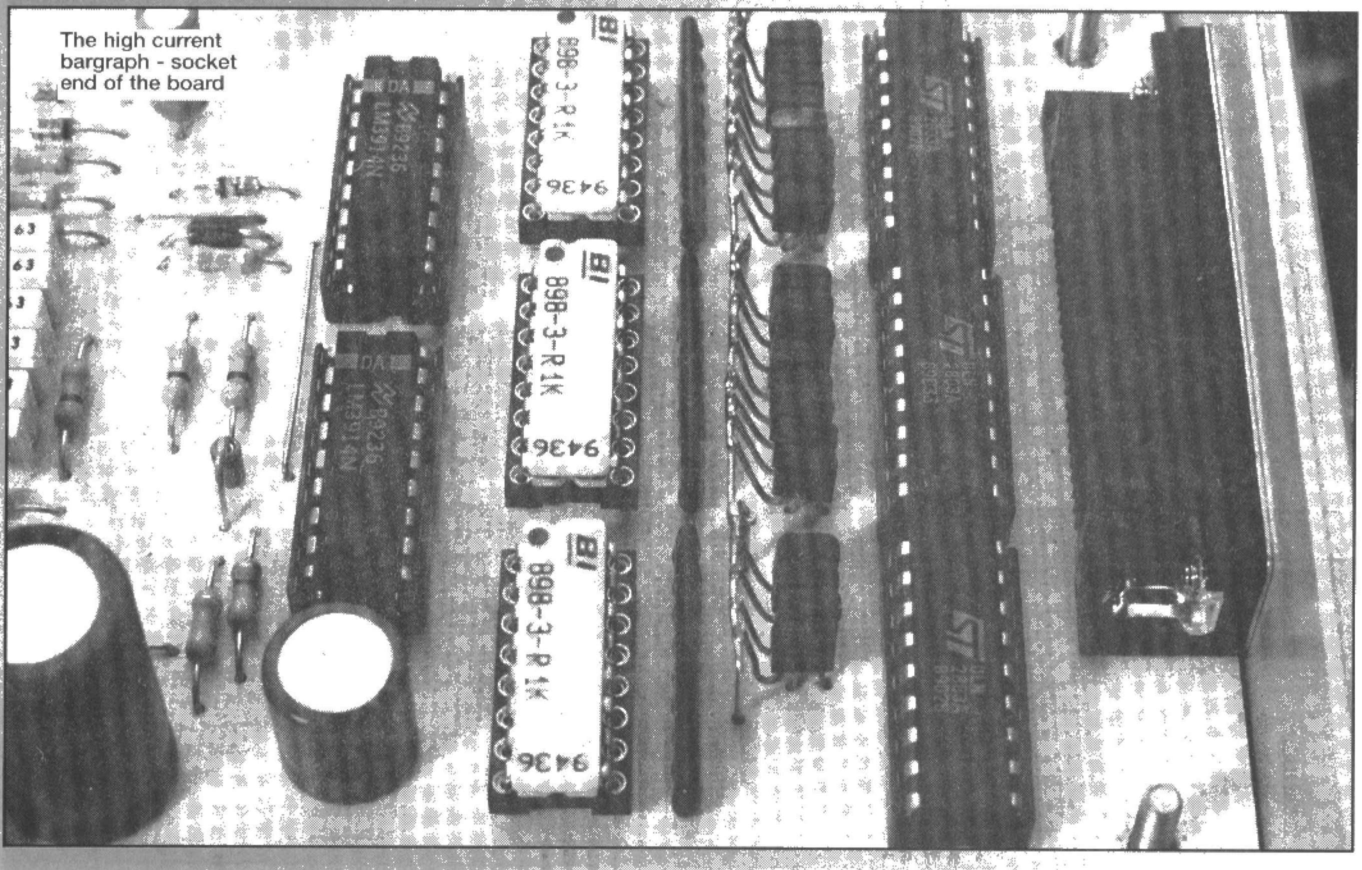

The high current bargraph - socket end of the board

Figure 18a: mounting a switch in the PSU box

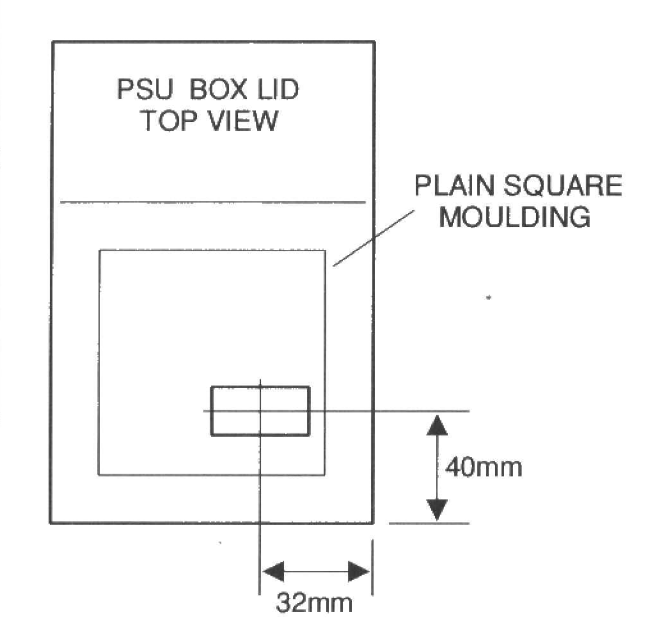
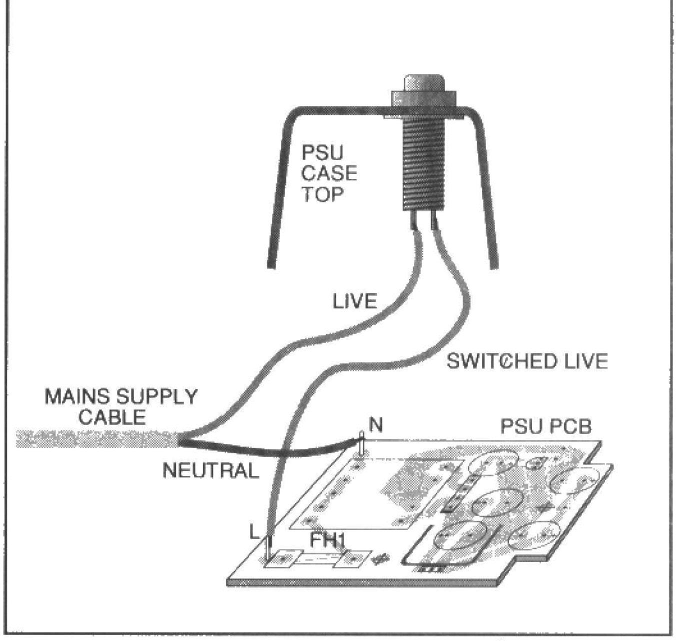


Figure 18b: the PSU mains switch wiring



buy a lead rather than make it yourself. The Rapid Electronics lead specified in the parts list is only £5.40. Connect the audio input to any standard line output, for example, a tape deck output or amplifier record output. You might need to make a phono Y splitter cable (okay as the loading is minimal), if you use an occupied record output from a hifi amplifier.

Although not designed as such, you can drive the bar graph circuit direct from speaker outputs, but to do this you must fit a 100K resistor in series in the signal input line. Due to the varying listening levels with speakers, regular adjustment of VR1 will be required.

Set VR1 fully off (anticlockwise) and VR2 to about mid point. Now gradually increase VR1, with a typical music signal, until the display is pulsating to your taste. The best effect is where the display pulsates from about 30% to 90%. Adjust VR2 for more gain if the signal level is too low. You can view the LED display directly or use the reflected light to good effect. The LED light output is very bright so the display looks impressive when hidden from direct viewing so that the light output is reflected off a nearby surface. If someone does build a giant multi-frequency spectrum analyser version, drop me a line or send me a video - it will be great to see one in action.

Power supply for the basic version

The power supply for the low current version is shown in figure 16. This will also be suitable for the high current version if you use the display as detailed, but you will need to add a high current supply (which I have left for you to design) to PL4 pins 1 and 2 if driving filament lamps, and break the loop going from PL4 pins 2 and 6.

The PSU circuit

The power supply, as shown in figure 16, is a standard split rail design but with quite high value capacitors. 240V AC mains is transformed down to two 12V AC secondaries. These are arranged to provided a centre tapped supply and then full wave rectified by BR1. C19 to C23 are reservoir capacitors. The +17V and -17V smoothed DC from BR1, C19, C20 and C23 is regulated to plus and minus 12V by Q22 and Q23 respectively. C21 and C22 provide additional reservoirs for the +12V supply.

Should you find that the -12V regulator (the 79L12) oscillates, you can add a 10uF capacitor to its out put, but this should not normally be necessary.

Power supply construction

Q22 can be a standard 1A 7812 regulator but the 2A 78S12 performed better on test. C19 to C22 should not be physically larger than 17mm diameter or 30mm high due to the fairly limited space. Following figure 17, firstly, solder the five Veropins, BR1, Q23, and fuse holder into the PCB. Then insert and solder C19 to C23 flat to the PCB. Attach Q22 to the heatsink with an M3 6mm screw and nut (an insulator is not required) and solder the assembly into the PCB with the heatsink flat to the board. If you have a hot glue gun handy, drop a few blobs of glue around the heatsink to secure it to the board. Finally, fit and solder the mains transformer T1 flat to the board, and attach the appropriate cables to the Veropins.

If the specified case and parts are used. no earth connection is required as the unit will be double insulated, so only 2-core mains cable will be needed. The integral On/Off switch is optional but if fitted, ensure it is fitted as shown in figure 18 due to space restriction and to avoid contact with other components. Use heat shrink or rubber sleeving on the switch connections and fit the plastic fuse cover to avoid mishaps with mains voltages. Please use cable grommets and don't knot the cable to prevent it being pulled - use a proper clamp or tight plastic cable tie. Only two of the three case mounting points are used and I added a 20mm square self adhesive foot, cut in half, fitted under the PCB (directly under the transformer) for added support. Use number 4 by 10mm self tap screws to secure the board to the case. The 12V DC supply cable used was actually a length of three core 3A mains cable attached to a 3 pin DIN plug. Ensure that pin 1 connects to -12V, pin 2 to 0V and pin 3 to +12V to conform with the component overlay and circuit diagrams. The usual care should be exercised when building and testing mains operated circuitry - ideally by using a mains isolating transformer while the power supply unit is open.

PARTS LIST for the Giant Bargraph Light Show

Resistors (all 0.25W unless specified)

R1	6K8
R2	22K
R3, R7, R8	10K
R4	330K
R5	1M
R6, R22	100K
R9, R10, R13, R14	15K
R11, R15	27K
R12, R16	47K
R17	220R
R18, R19	680R
R20, R21, R23-R42	100R

VR1 100K cermet Spectrol 63MT (Farnell 347-358) (Maplin WR44X)
VR2 10K cermet Spectrol 63MT (Farnell 347-322) (Maplin WR42V)

Capacitors

C1	10uF 63V radial electrolytic
C2	1nF mini polyester
C3	1uF polyester layer
C4	1uF 25V axial electrolytic
C5	100pF ceramic
C6,C7,C8,C9,C10,C11,C12,C13	See text (filter capacitors, select according to frequency)
C16, C17	100nF mini polyester
C14	4u7 25V radial electrolytic
C15	470uF 25V radial electrolytic
C18	1000uF 16V radial electrolytic

Semiconductors

IC1	TLO74 or TLO84 quad op amp
IC2, IC3	LM3914 bar graph
Q1	2N3819
D1-D3, D6	1N4148
D4, D5	BZY88C4V7 zener
LED1 - LED100	Bright red 10mm LED (Maplin UK53H) (Rapid 55-0330 or 55-0340)

Miscellaneous

PL1	8 way Molex pin wafer (Rapid 22-0975)
PL2, PL3	3 way Molex pin wafer (Rapid 22-0955)
PL4	2 way Molex pin wafer (Rapid 22-0950)
PL5 to PL6	25 way D type male to male lead (Maplin DD25C) (Rapid 19-0592)
SK1	8 way Molex pin housing (Rapid 22-0930)
SK2, SK3	3 way Molex pin housing (Rapid 22-0910)
SK4	2 way Molex pin housing (Rapid 22-0905)
SK5	25 way PCB mounting D type female (Maplin FG27E) (Rapid 15-0185)
SK6	25 way chassis mount D type female (Maplin YQ49D) (Rapid 15-0160)
SK7	3 pin DIN chassis mount socket
SK8	Single chassis mounting phono socket (Rapid 20-0215)

Molex crimp pins for SK1 to SK4 (13) (Rapid 22-1097)
14 pin DIL IC socket (1)
18 pin DIL IC socket (2)
Printed circuit board 20mA version
DB4 Case (Maplin BN54J)
White trunking 38mm x 24mm x 1.5m (DIY or electrical retailers)
M3 screws, nuts and 15mm spacers

Additional parts for high current version

SIL1, SIL2, SIL3	10K 8 resistors one end commoned (Maplin RA30H) (Rapid 63-0230)
DIL1, DIL2, DIL3	1K 8 resistors (Maplin DL86T) (Rapid 63-0645)
IC4, IC5, IC6	ULN2803 transistor array
Q2 to Q21	ZTX500

Printed circuit board 500mA version
16 pin DIL IC socket (3)
18 pin DIL IC socket (3)

PARTS LIST FOR THE BARGRAPH POWER SUPPLY

Capacitors

C19, C20, C21, C22	2200uF 25V radial electrolytic
C23	470uF 25V radial electrolytic

Semiconductors

BR1	SKB2/02L5A (Rapid SKBP02) (RS 261-491)
Q22	L78S12CV (Maplin UJ56L)
Q23	79L12 (Maplin WQ86T) (Rapid 79L12)

Miscellaneous

F1	T315mA 20mm fuse
T1	PCB mounting transformer 12V-0V-12V 1A (Maplin DM13P)
PL7	3 pin DIN plug

20mm PCB mounting fuse holder (Maplin DA61R) (Rapid 26-0165)
Clear fuse holder cover (Maplin DA62S) (Rapid 26-0170)
Redpoint TV40 heatsink for Q22 (Maplin FG55K) (Rapid 36-0250)
PSU case (Maplin YU32K)
Cable grommet (2) (Maplin JM16S)
Power supply PCB
1mm single sided Veropin (5)
2 core cable 16/0.2mm 3A
3 core cable 13/0.2mm 2.5A
Push button latching mains switch (Maplin FG46A)
Mains plug

All the components should be easily obtainable at Maplin or Rapid Electronics. The author can supply any parts except the printed circuit boards. For prices send a stamped addressed envelope to ETI Bar Graph, 21 Crossgates Avenue, Leeds, West Yorkshire, LS15 7QF. Sorry - no phone calls or callers please. PCB master laser film prints, directly for use with UV light and photosensitive board, are also available from the author at £1 each pattern.

Component suppliers
Maplin Electronics, Rayleigh, Essex, SS6 8LU.
Rapid Electronics Ltd, Heckworth Close, Severalls Industrial Estate, Colchester, Essex, CO4 4TB.
Farnell Electronic Components, Canal Road, Leeds, LS12 2TU.
RS Components (Electromail), Corby, Northants.

The ETI Micro Amp Part 3

Barry Porter concludes his professional-standard stereo microphone amplifier with a description of the power supply requirements and two PSU designs.

In the final part of our microphone amplifier project we describe two power supply designs, one very basic, and a more complex high-reliability model, to power the MicroAmp according to different users' requirements

The power supply unit

The MicroAmp requires four separate power rails:

Signal supply - Vs	+/-16V at 250mA
Relay and LED supply - Vr	+13V at 200mA
Phantom power - Vp	+48V at 30mA

These voltages could easily be supplied by integrated regulators, but I felt it preferable to use discrete circuitry for all but the phantom supply. The suggested power unit is shown in block form in figure 12, with circuit details in figures 13 (Vs stabiliser) and 14 (Vr and Vp stabilisers). The component layout for the Vs stabiliser is shown in figure 17, and for the Vr and Vp stabilisers in figure 18..

The Vs and Vr stabilising circuitry is of a conventional type, with an output capability of approximately 5A. The phantom supply can deliver about 0.5A, so a single power unit can be used to supply more than one MicroAmp - in fact, it shouldn't complain if a dozen are connected to it. The power unit may also be used with other signal processing equipment, such as a ParaBender equaliser, or even to supply a small mixing console.

If anything in this world needs to be over-engineered, it is your power supply unit. By building in a large excess power capability, the unit should not be strained in any way, and as a consequence should be as near to totally reliable as possible.

Figure 12: the block diagram of the power supply

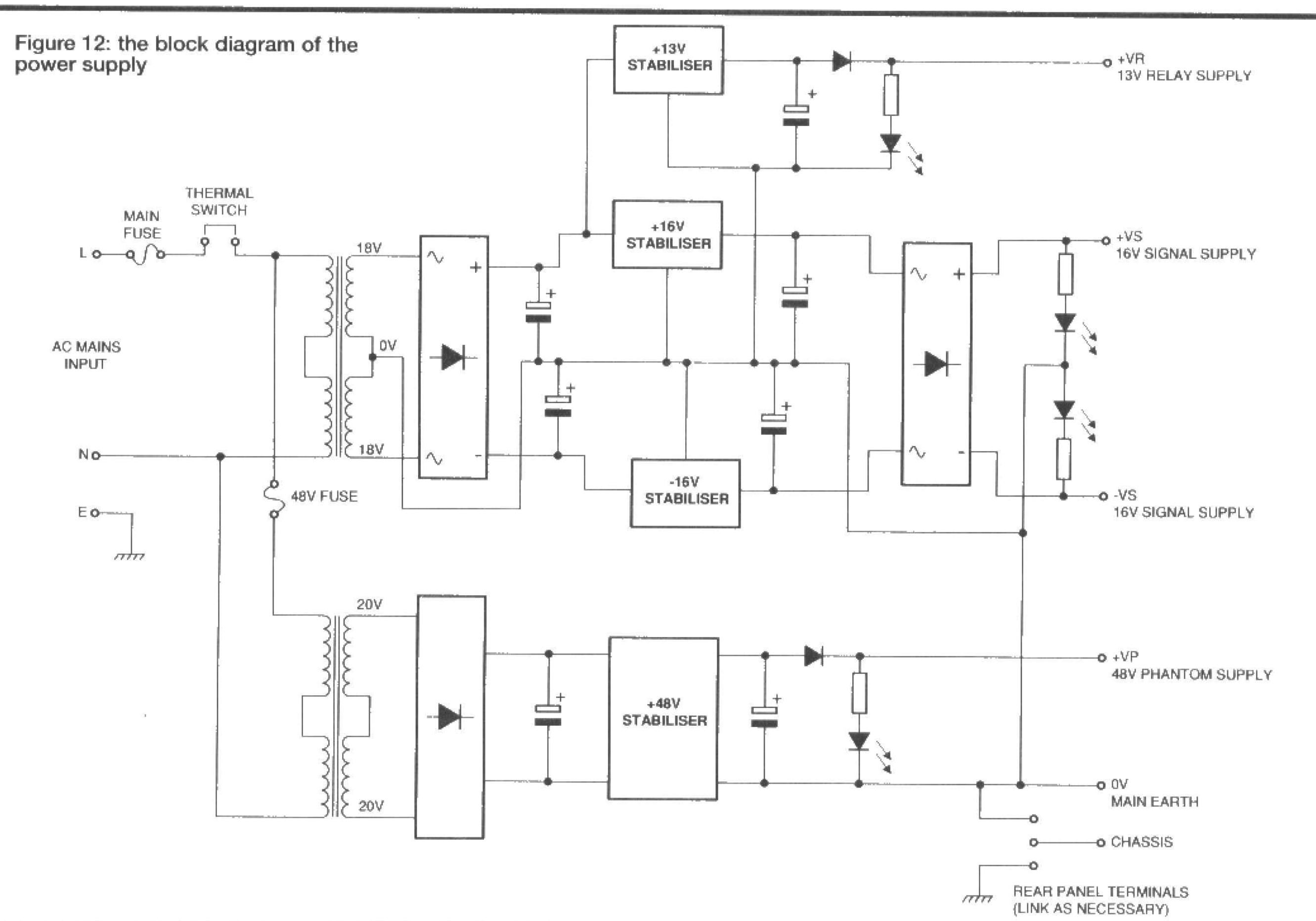


Figure 13: the circuit of the +/-VS stabliser

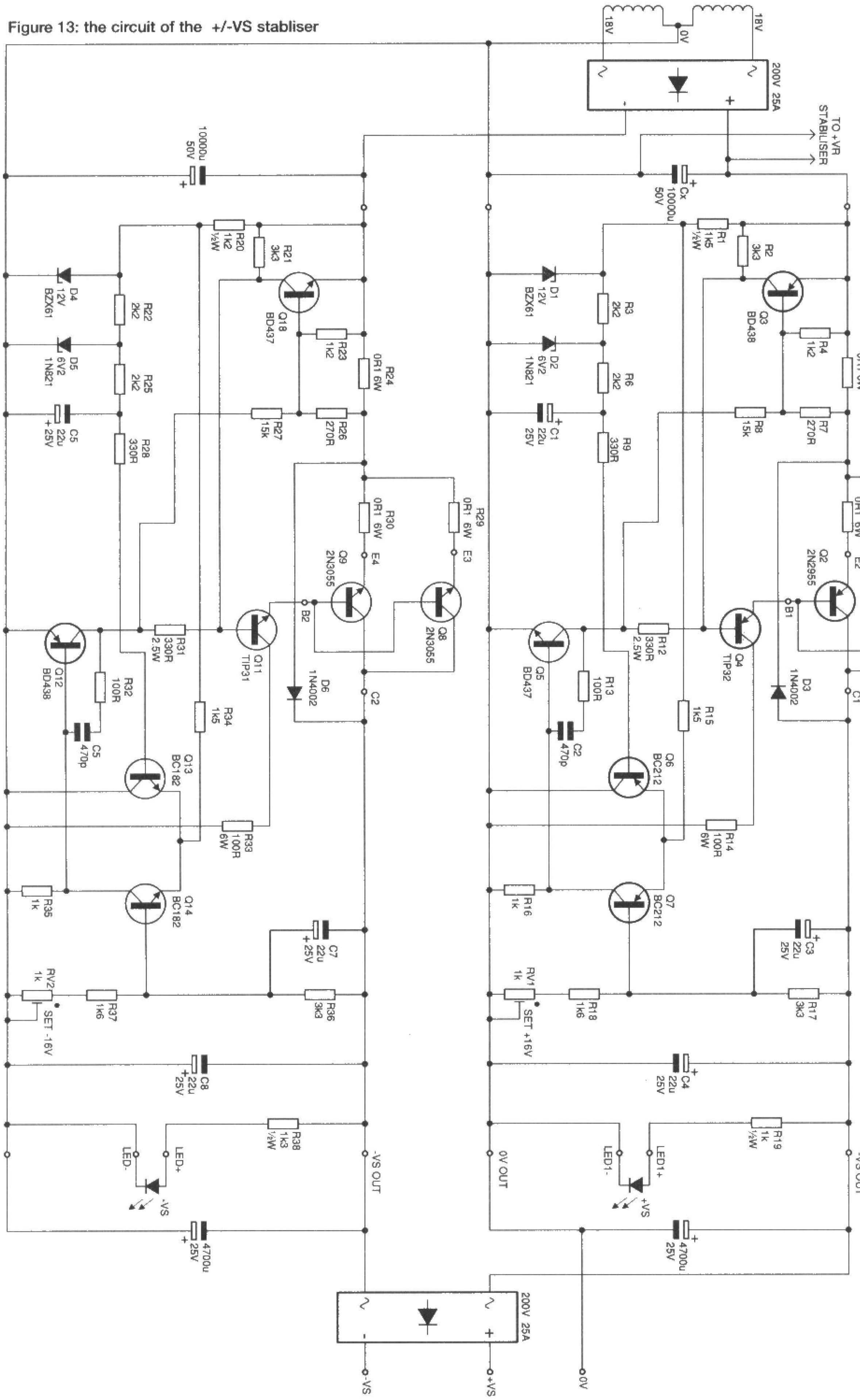


Figure 14: the circuit of the +VR and +VP stablisers

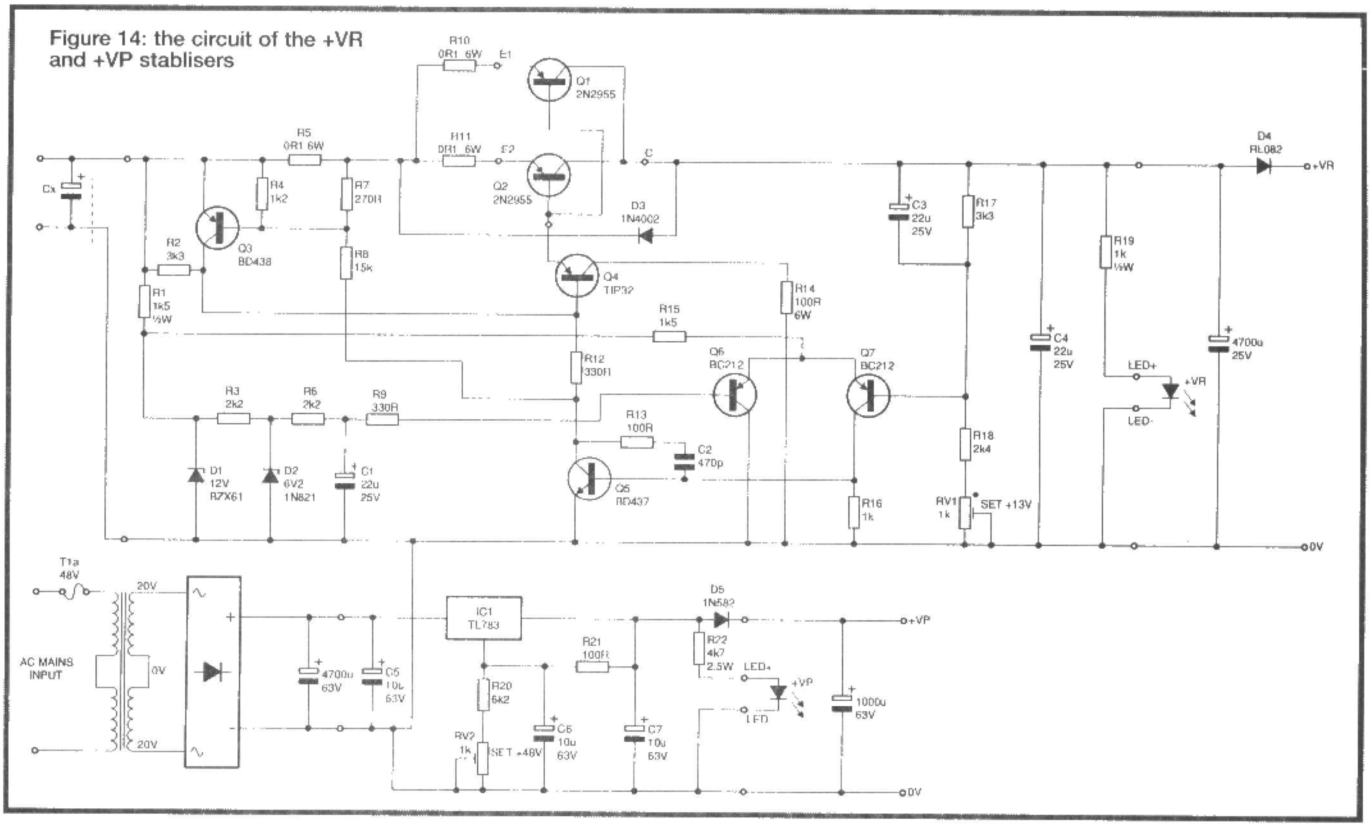
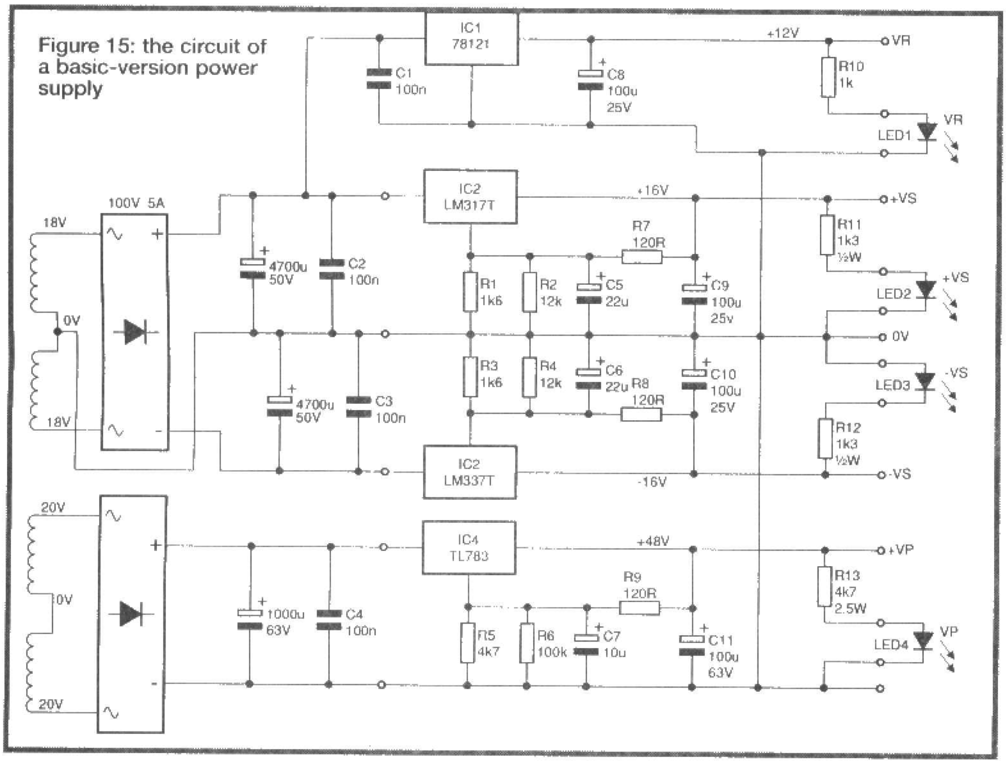


Figure 15: the circuit of a basic-version power supply



However, if cost is the main consideration, and power is only required for a single MicroAmp, a far simpler unit as shown in figure 15 will be adequate.

The larger supply may be built into any suitable enclosure, but if it is likely to be used to the limit of its performance, sufficient heatsink area must be provided.

A 19-in x 2U case with external heatsinks is probably the best choice, as up to 150 watts has to be dissipated. For lower current requirements, using a case with internal heatsinks, or even mounting the stabilising transistors directly onto the enclosure, may be acceptable.

The ratings of the two mains transformers will also depend upon the output requirement. For a continuous drain of 5A on each of the Vs and Vr rails, the main transformer should be rated at:

I(dc) x 1.61 x Vsec = 15 x 1.61 x 36 = 869VA

This makes for a mighty large transformer, not to mention a mighty expensive one. If money is no object, most transformer manufacturers will wind anything you require, but unless you are ordering in large quantities, expect to pay a pretty stiff premium for a single unit. If you do decide to take this route, it is worth having separate secondaries wound for the Vr and Vp supplies. A suggested design is shown in figure 16.

If you are using a standard transformer, the VA rating should be as large as possible - preferably 500VA, but if cost or size mean using a smaller one, it will be necessary to increase the secondary voltage to 20-0-20V RMS to maintain the raw dc voltage at a sufficiently high level for the stabilising circuitry to operate correctly.

For a 0.5A phantom power capability, transformer T2 needs to be:

0.5 x 1.61 x 40 = 32VA

This should cause no problems, except that no-one

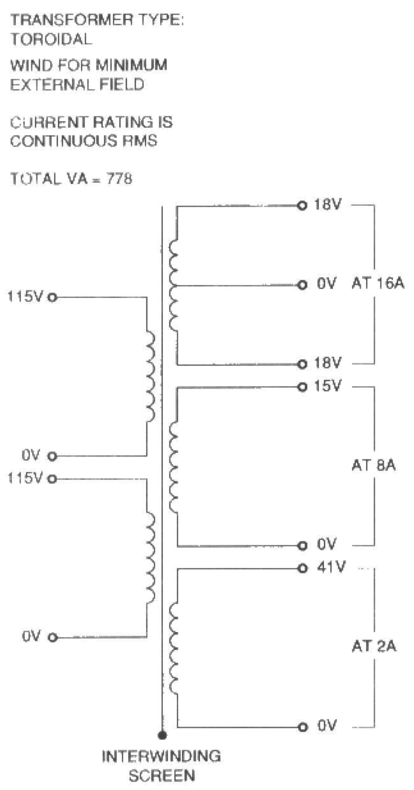


Figure 16: the design of the MicroAmp custom mains transformer if required (see text)

appears to make a standard transformer with the required voltage and current outputs. Luckily, a suitable 50VA one is available, which does not suffer a great size penalty.

Stabilising circuits

The Vs and Vr stabilising circuitry is similar in all respects except for the polarity reversal of the active components in the -Vs supply.

Using the +Vs circuit (figure 13) as an example, the stabilising transistors, Q1 and Q2 are controlled by comparing the attenuated output voltage to a reference voltage established by precision zener diode, D2. In operation, if the output voltage increases beyond its pre-set value, transistor Q7 will be turned off, as its emitter potential is fixed at 0.6V above the 6.2V reference by the Vbe drop of Q6. As Q7 turns off, the voltage across resistor R16 will fall, turning Q5 off. This allows R2 to turn Q4, and hence Q1 and Q2 off until the output has fallen to the required voltage. Obviously, if the output voltage falls, the reverse happens and Q1 and Q2 turn on until the correct output voltage is established.

Under overload or short circuit conditions, the voltage developed across sense resistor R5 starts Q3 turning on, which diverts base current from Q4, turning off Q1 and Q2. The low output voltage causes Q7 and hence Q5 to turn hard on, and the low collector potential of Q5 pulls Q3 harder on via resistor R8, thereby introducing a foldback action which limits dissipation in the stabilising devices.

Any noise finding its way onto the output rail is fed via capacitor C3 to the base of Q7, and is cancelled by the resulting negative feedback action.

Why the bridge rectifier?

By now you are probably wondering why the output of the stabiliser feeds a bridge rectifier? All that is strictly necessary is a single diode capable of handling the maximum output of the supply but, for a given current, rectifier bridges tend to run much cooler than single devices. So, why diodes? They are not absolutely essential, but imagine you are in the middle of a recording when your power supply calls it a day and your incoming signal dies away to a level inversely proportional to your blood pressure. You may have a spare supply with you, but at best it will take several seconds to plug it in and switch on.

Now, consider your peace of mind if you had two supplies running at the same time, arranged so that if one dies, the other would carry on without a sigh.

The diodes allow the outputs of two or more supplies to be joined together, either to provide back-up in case of failure, or to increase the available current for powering large mixing consoles or whole racks of MicroAmps.

To achieve this, the power output connector should be duplicated so that units can be chained together with short interconnection leads.

The phantom power supply uses a high voltage regulator (figure 14, IC1) with conventional circuitry. Note that in order for the TL783 to operate correctly, it must have an output load - normally provided by the indicating LED. If for any reason you decide not to fit this, the bottom of resistor R22 must be connected to the output ground.

For reliability, the Vs and Vr stabilising transistors should be metal can TO3 types, as plastic devices do not seem to have a very good track record in power supplies. If your heatsink is flat backed, the transistors can be mounted onto a piece of 38 x 38 x 5 angle alloy which is attached to the heatsink with plenty of M3.5 screws and a good dollop of thermal compound over the mating faces.

I do not recommend that your power supply is fitted with a mains switch, unless you feel like investing in one with a positive locking action with a removable key. Power units tend to find their way onto the floor, where feet also go, and you can bet your life that when a foot meets a switch, it will always be moving in the "Off" direction.

I have made only outline recommendations regarding the type of enclosure, external heatsinks etc., and have not specified connectors or indicating LEDs, as I feel that a browse through the Electromail or the Maplin.catalogue will enable most constructors to choose suitable parts for their own requirements.

The simple version ...

Due to the simplicity of the basic power supply, no PCB layout has been prepared for that version, and the components used may be changed at will. If there is enough demand we may come up with a "simple" layout, but most of you will be able to do a design to suit yourselves.

Obtaining the parts

Where possible, components have been chosen which are stocked by Electromail (Electromail Ltd., PO Box 33, Corby, Northants NN17 9EL Tel:01536-405555).

Other parts can be supplied by: Audio Solutions Ltd, 9b Ashbourne Parade, Hanger Lane, London W5 3QS Tel 0181 998 8127 Fax 0181 997 0608

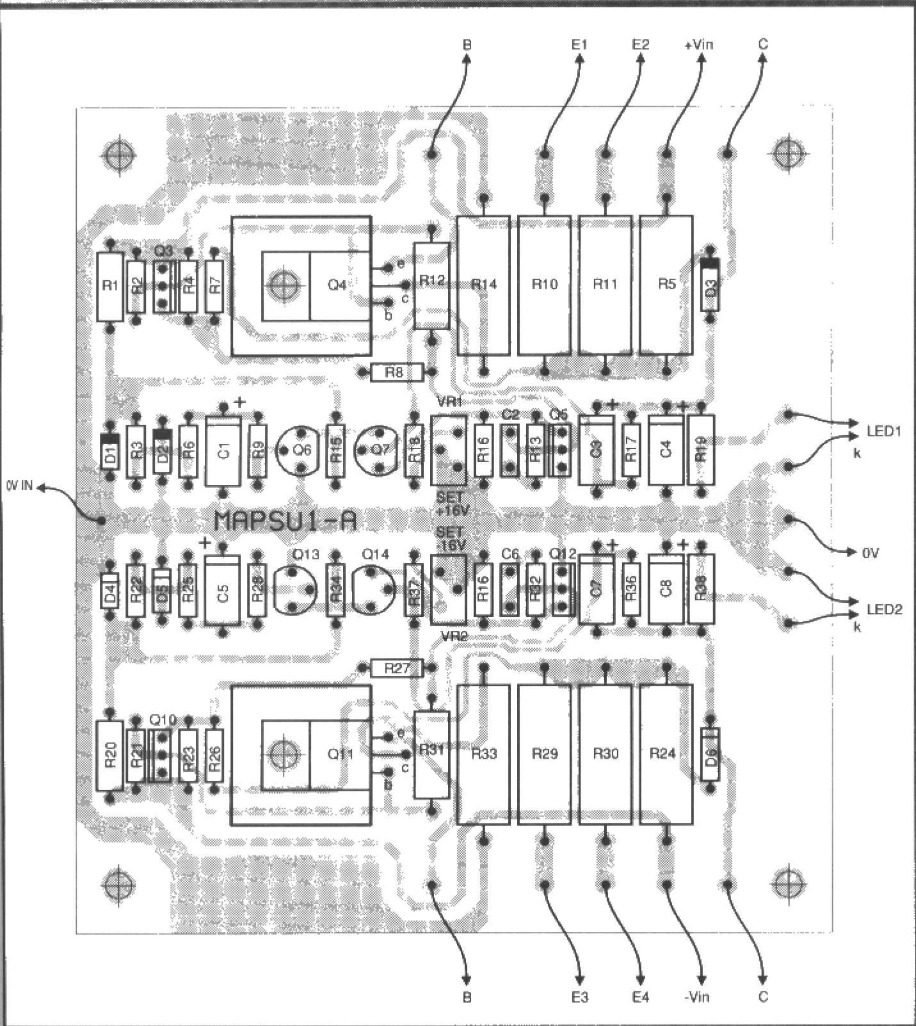
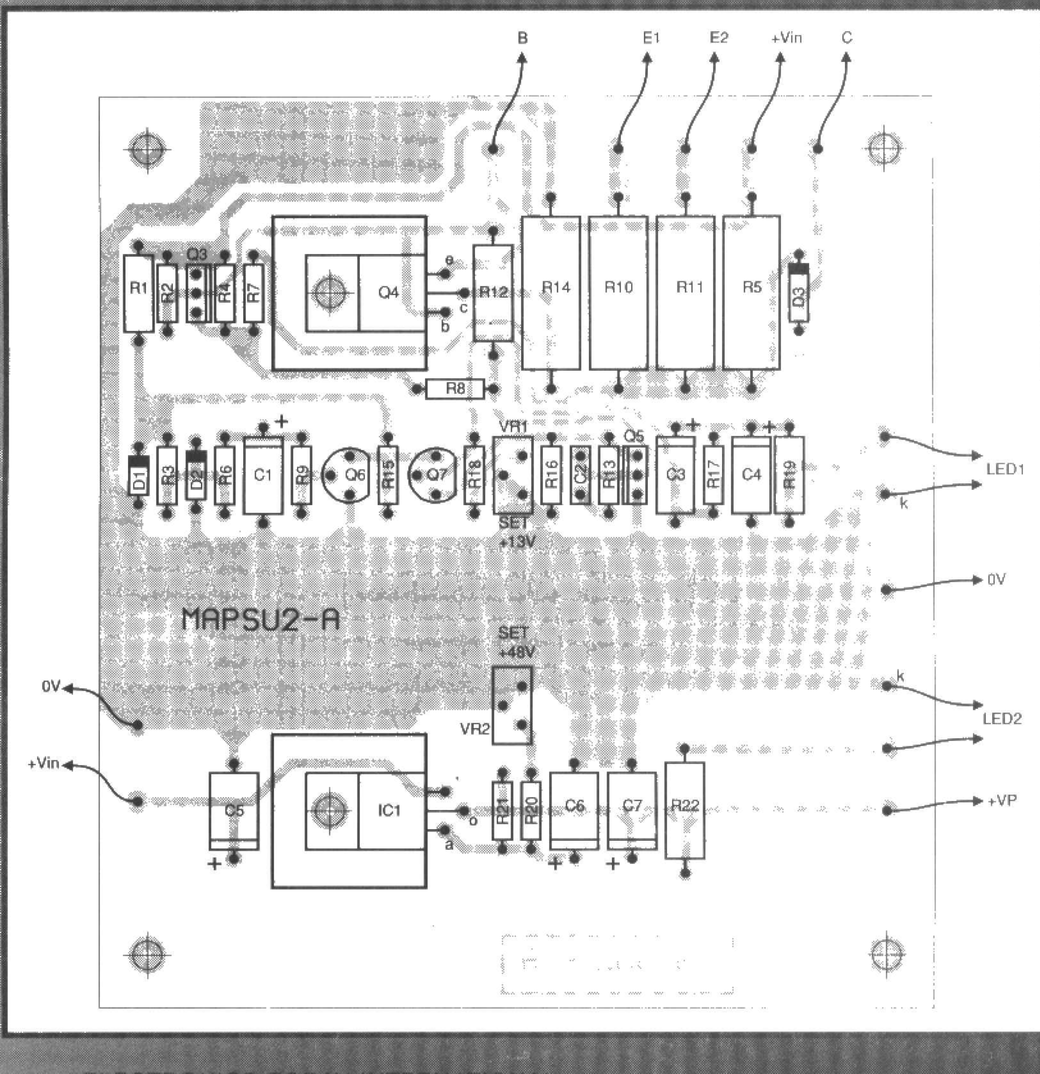


Figure 18: the component layout of the +Vr and +Vp stabiliser modules

Figure 17: the component layout of the plus or minus Vs stabiliser module



PARTS LIST for the Micro Amp Power Supply

Figure 13 [Vs Stabiliser]

Resistors

R1,R20	1k5 0.5W	149-717
R2,R17,R21,R36	3k3	148-629
R3,R6,R22,R25	2k2	148-584
R4,R23	1k2	148-528
R5,R24,R29,R30	0R1 6W	159-253
R7,R26	270R	148-360
R8,R27	15k	148-770
R9,R28	330R	148-382
R10,R11	0R1 6W	159-253
R12,R31	330R 2.5W	152-527
R13,R32	100R	148-269
R14,R33	100R 6W	159-433
R15,R34	1k5	148-540
R16,R35	1k	148-506
R18,R37	1k6	148-556
R19,R38	1k3 0.5W	163-628
VR1,VR2	1k	375-900

Capacitors

C1,C3,C4,C5,C7,C8	22uF 25V	107-000
C2,C6	470pF	113-308

Capacitors not on PCB:

2x 10000uF 40V	105-414
2x 4700uF 25V	105-290

Diodes

D1,D4	12V BZX79	283-738
D2,D5	6.2V 1N821	850-237
D3,D6	1N4002	261-154

Transistors

Q1,Q2	2N2955	293-684
Q3,Q12	BD438	109-078
Q4	TIP32	295-494
Q5,Q6,Q10	BD437	299-345
Q6,Q7	BC212	296-122*
Q8,Q9	2N3055	293-511
Q11	TIP31	295-488
Q13,Q14	BC182	296-087*

Note: The BC212 and BC182 transistors supplied by Electromail are not suitable, as they have a centre collector pin-out. The part numbers given are for alternative devices, BC547 and BC557.

Additional components:

Bridge Rectifiers	264-888 [x2]
Heatsinks for Q4 & Q11	402-951 [x2]

Figure 14 (+Vr and +Vp stabiliser]

Resistors

R1	1k5 0.5W	149-717
R2,R17	3k3	148-629
R3,R6	2k2	148-584
R4	1k2	148-528
R5	0R1 6W	159-253
R7	270R	148-360
R8	15k	148-770
R9	330R	148-382
R10,R11	0R1 6W	159-253
R12	330R 2.5W	152-527
R13	100R	148-269
R14	100R 6W	159-433
R15	1k5	148-540
R16	1k	148-506
R18	2k4	148-590
R19	1k 0.5W	149-694
R20	6k2	148-685
R21	180R	148-326
R22	4k7 2.5W	152-684
VR1,VR2	1k	375-900

Capacitors

C1,C3,C4	22uF 25V	107-000
C5,C6,C7	10uF 63V	107-088
C7	10uF 63V	107-088

Capacitors not on PCB:

	4700uF 25V	105-290
	4700uF 63V	105-329
	1000uF 63V	105-335

Diodes

D1	12V BDX79	283-738
D2	6.2V 1N821	850-237
D3	1N4002	261-154
D4	40A stud	262-624
D5	1N5402	263-065

Transistors

Q1,Q2	2N2955	293-684
Q3	BD438	109-078
Q4	TIP32	295-494
Q5	BD437	299-345
Q6,Q7	BC212	296-122*
IC1	TL783	302-255
T1	40V Transformer	208-800
Br1	200V 2A	183-4078

Figure 15 [Basic Power Supply]

Resistors

R1,R3	1k6	148-556
R2,R4	12k	148-758
R5	4k7	148-663
R6	100k	148-972
R7,R8,R9	120R	148-281
R10	1k	148-506
R11,R12	1k3 0.5W	163-628
R13	4k7 2.5W	152-684

Capacitors

C1,C2,C3,C4	0.1uF	115-988
C5,C6	22uF 25V	107-000
C7	10uF 63V 1	07-088
C8,C9,C10	100uF 25V	107-022
C11	100uF 63V	107-117
Ca	4700uF 40V	106-877 (x2)
Cb	1000uF 63V	105-335

Semiconductors etc.

IC1	7812	633-032
IC2	LM317T	631-317
IC3	LM337T	630-998
IC4	TL783	302-255
Br1	KBU4D	630-803 (x2)
T1	18V Transformer	196-561
T2	20V Transformer	196-319

ETI ELECTRONICS TODAY INTERNATIONAL News...

Weekend wind workshops in Wales

ETI readers will have followed with interest Douglas Clarkeson's series on alternative energy sources. Here is a chance for further involvement with alternative energy; have you ever wanted to build a wind generator, solar PV, water heating system or another alternative technology project? Robert Keyes GW4IED of Keysolar Systems is holding a series of practical workshops in which people of any ability can work with other people in a well-equipped workshop on pians provided or on their own designs. The workshops are based in Newport, Gwent, near to junction 25 of the M4, from 12am to 6pm on Saturdays and 9am to 4pm on Sundays, starting in November 1996 and running through 1997. There is hotel and B&B accommodation available nearby, and hardstanding for caravans on the site.

For more information, tel or fax 01633 280958 during office hours, or write to Keysolar Systems, 4 Glanmor Crescent, Newport, Gwent NP9 8AX.

Reading launches new engineering courses

Reading University is launching a new range of four-year degree courses leading to Master of Engineering (MEng) qualifications. Reading's Engineering Department, one of the few in the UK whose teaching quality was assessed by the Higher Education Funding Council as "excellent" has designed the courses to be comparable with the best professional courses on offer in the rest of Europe, combining traditional academic studies with extended project work carried out in close collaboration with industry.

In addition to this, collaboration between the University and Reading College of Arts and Technology gives students completing HND courses in Electrical and Mechanical Engineering the opportunity to join the relevant University degree course at second year level. The University has also worked with local industry both to assist with technical support and on joint project work.

Students started in the disciplines of Mechanical, Electronic or Integrated Engineering at the start of the autumn term.

The University of Reading can be contacted at Whiteknights, PO Box 217, Reading RG6 6AH.

The MILLENNIUM Problem - it may be later than your computer thinks

The task force set up earlier this year by the Computing Services and Software Association and the Confederation of British Industry to address the "Millennium Problem" - the misreading of the date "2000" and subsequent numbers higher than 1999 by computer software that interprets dates by the final two digits - has recently completed its first major conference aimed at company chiefs.

"Computer companies still selling non-millennium-compliant software and services must come clean and make the position clear to the customer", said Science and Technology Minister Ian Taylor, adding that Chief Executives should talk to shareholders now about how their companies will take action to maintain trading through the turn of the century.

The task force's primary objective is seen as achieving 100% awareness of the problem by board-level executives by the end of March 1997, so that it can be eradicated before it becomes necessary for computer systems to start using third-millennium dates on a large scale for items such as insurance renewals and pension payments.

The interpretation of dates by the last two digits - reading 1996 as "96", for example - has been a functional approach since business computing was invented earlier this century - but now the industry of the future finds that the future is almost here - bringing crisis, if software is not updated. Systems seeing the date "2000" will interpret it as "1900" or even as no date at all. This will throw time-sensitive data, such as maturing investments, into chaos.

For many companies, it may be expensive to remove the anomaly from software which may involve several different suppliers. However, the losses arising from a malfunction affecting the records of all customers, members, or assets, could cause business failures.

Fortunately, forward-thinking software developers have already built this capability into their software, but it has been ignored by many. The task force expects to develop an educational programme including a helpline, newsletter, a World-wide web Internet site, workshops, conference and videos, and recruit help from suppliers, user groups and business support organisations to warn people of the problem.

Anyone who believes that their business or personal software may need to be updated in this respect should seek information from their software suppliers, as pressure on suppliers is likely to increase as the year 2000 approaches.

Review

User-Driven Innovation: The World's First Business Computer
By David Caminer, John Aris, Peter Hermon and Frank Land
Hardback £35.00
McGraw-Hill Book Company Tel. 01628 23432

It is one of those little-known well-known facts that the first computer to run regular business programs was developed by a company famous for its teashops.

J. Lyons & Co. (best remembered as Joe Lyons) was by 1950 England's leading caterer, and a supplier of consumer bakery on a massive scale. In the late 1940s "computors" were still "the Electronic Brain" (the American ENIAC was in the news), and almost mythical, in the public mind. However, the corner was about to be turned. Strange though it seems that a caterers should undertake the development a revolutionary accounting machine, Lyons was already respected for its dynamic management methodology. Lyons considered the whole business, which was a very large one, rather than let departments run themselves. With several hundred teashops taking daily deliveries, this approach was probably pivotal.

After World War II, the accounting and stock-tracking paperwork needed crowds of clerks making repetitive calculations and reconciliations year-in, year-out, costly in labour and increasingly unpopular as a career. Two members of the Chief Comptroller's department, T.R. Thompson and Oliver Standingford, went to the USA to survey the latest in office management practice and equipment. They were unimpressed with the former, but deeply impressed by the ENIAC project at Princeton University and by plans at Prudential Insurance in New Jersey to build an electronic billing machine.

Having discussed their findings and reported to the Board, Chief Comptroller John Simmons immediately gained a grant of £3,000 plus an "electrical assistant" from Lyons for the Maths Lab at the Cavendish Laboratory, Cambridge University, to pursue work on their electronic calculating machine, EDSAC. On 6th May 1949, EDSAC became the first stored program computer to operate in a practical way, by calculating a sequence of prime numbers. Dr. Maurice Wilkes phoned Lyons, where a board meeting was taking place. Within minutes the Chairman gave his staff the go-ahead for full-scale development work on the first business computer.

Simmons named the proto-computer LEO, for Lyons Electronic Office, with a completely straight face, and development of the business systems, to which this book is chiefly dedicated, began. The core hardware principle of EDSAC now worked, but ahead lay the task of inventing systems analysis, writing programs to fit a tiny amount of storage (as memory was then called), and redesigning the hardware with appropriate input, output and storage devices. Work was commissioned on magnetic tape storage, but this proved abortive. Punch cards and paper tape were used for running programs, with mercury tube storage, and magnetic wire drums.

Leo ran the first routine business application just two years later in November 1951, under a development staff of a mere 20 people. The LEO project became the reliable source of Lyons' management accounting, as well as bureau services and in-house installations for clients, becoming LEO Computers Ltd. in 1959.

This book is primarily the historical reminiscences of several members of the development team, notably systems analyst David Caminer. The underlying thread is the complete dedication of the team and the rigorous checking procedures carried out on all the coding in the quest for compactness and reliability. Many of the individual chapters cover the story of a specific contract by one of the senior team members who worked on it. The chapter by John Lewis on the Glyn Mills Bank Army and Air Force Officers Payroll gives insight into the design complexities of a particularly complex payroll program recording deductions and allowances (of which the offers' pay mainly consisted) arriving at irregular times onto a small memory. Although the model in service here is the Leo II/5 (installed in 1959) the main memory store "consisted of 2048 addressable short words - equivalent to under 10,000 4-bit characters in today's parlance. (Even a modest word processing computer has a memory of 512,000 alphanumeric characters.) Bank account numbers had not been invented yet, and the process was not aided by the payroll records being filed by name. - "one family with a history of several generations of service in the army had a surname of 27 characters".

But I found that the most trenchant section was The Widening Field, by Frank Land, who started in Lyons as a trainee programmer and rose to Chief Consultant, later returning to academia to hold a Professor ship of Systems Analysis and other senior posts. Bluntly at times he gives a view of the problems of reconciling the technical enthusiasm of the LEO people with the less crystalline views of some of their customers, and the vital importance in those days of individuals with a strong faith in progress (touchingly, he calls them "champions" in the old sense of someone fighting for a cause) in getting companies to adopt computerisation at all. "We had confidence in our ability to understand what was needed that sometimes made up appear arrogant. But we too were capable of missing a real requirement or misjudging a situation." He concludes: "It is interesting that in 1995 the rhetoric of the day suggests that the way ahead lies in following the precepts we learned with J. Lyons and which we implemented with Lyons and our LEO customers over 30 years ago."

Eventually history overtook the LEO business, as office machine companies (such as IBM) brought in their own

systems to an existing customer base. One of LEO's weaknesses in the field may have been its devotion to creating efficient management systems rather than simply nodding to prospective customers' specifications. The divide between what the machine is best fitted to do, and what the non-technical client thinks it can best do had not been an issue at Lyons but, as in the 1990s, the gap was not so easily closed elsewhere.

As well as the story of the development of LEO, and of programming projects for customers from the Post Office to a truckers' magazine giveaway, the books reprints Thompson and Standingford's original technical report and some other items of interest. It is overtly stated that this volume's main purpose is to gather and preserve the historical records of this project before too many of the members grow much older (many of the original senior Lyons management are deceased), but some photographs, I think, would have helped the class of 1996 to appreciate the scale of the project.

Perhaps one unique side effect of studying the LEO story is that it is impossible to go for long without desiring to lay hands on a cup of tea and a bun, and equally impossible to feel guilty about doing so. That was, after all, the motive force behind the whole project.

LEO: The First Business Computer
By Peter J. Bird
Hardback £18.95 UK, £26.00 overseas
Hasler Publishing Ltd. Tel. 0118 978 1922

Peter Bird worked for Lyons as an information technology expert from 1964 to 1991. His book first came out in 1994, and provided part of the impulse for members of the LEO development team to come together and produce the more recent volume reviewed above. Bird's book also covers the earlier history of J. Lyons and Co. Ltd., and, without in any way providing technical blueprints, contains a fair amount of technical information and illustration.

Told as a straightforward history compiled from the (in some cases very thorough) project records made by team members, and from interviews, this is a readable story that covers everything from the details of paper-tape splicing and punch-by-punch program checking to the kind of anecdote involving high-level visitors, a revolutionary and still highly experimental (that is, unreliable) piece of machinery, the best efforts of the personnel, and a doorhandle. Anyone who has taken part in hardware or software demonstrations to a deadline will recognise the situation at once. This is not, however, merely in jest, but an illustration of the constant parallel pressures of hardware reliability, software development, support and marketing brought to bear on the team, perhaps not so different from today except that the team was much smaller and the concept much more revolutionary than most of today's computing market. One pressure that they were not under was pressure of mass marketing ...

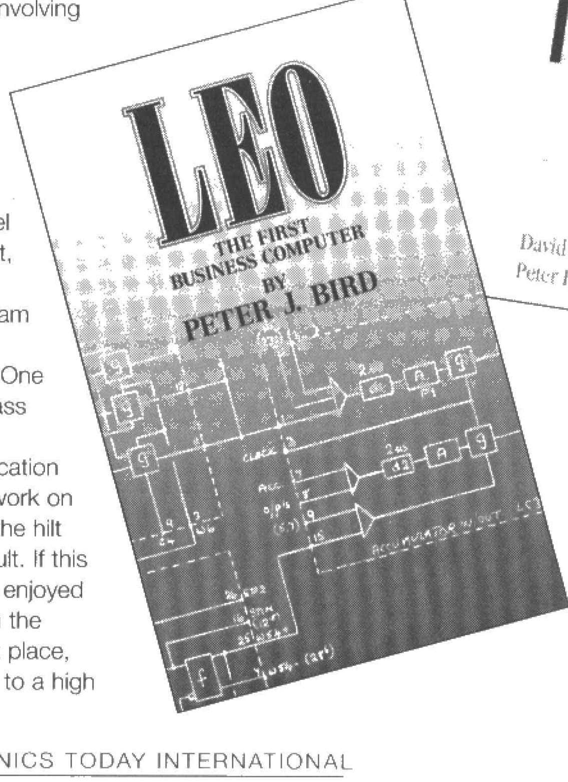
Again the emphasis is on the high calibre and dedication of the development team, fired by the opportunity to work on something new for an employer that backed them to the hilt and had an important practical use waiting for the result. If this book stresses the long hours rather than the high pay enjoyed by many of the team, and the cameraderie rather than the crisp critiques and occasional brisk sackings that took place, this is just another side to the story of a team working to a high standard under uncertain conditions .

LEO was overtaken, as we have said above, by the larger tide of history, but its most notable legacy may be that the development team dispersed into senior and influential positions throughout the growing computer industry, saying that they owed their experience to LEO; and that many of them keep in touch to this day.

Peter Bird's book has no fewer than 13 technical and statistical appendices, including one on program actions in LEO I and another one on the calculation and memory circuits. There are also considerable chapters following hardware and peripheral developments, and a number of diagrams and flow diagrams describing those developments. There are a large number of black and white photographs of the machines at work (and "down"), and of the electronic assemblies and experimental mercury delay tubes, which may be a revelation to anyone born in the PC age. I thought that "mini" computers were large when I left university in the 1970s - I had no idea what "large" really meant.

Photos of the development team at work, too, provide an insight into changing times - this was well before the days of Jesus sandals and beards, but the comparative formality seems to have damped no-one's enthusiasm. The text is both readable and informative to old hands and new students.

Readers may also hear with feeling hearts that Lyons' original move into catering was to provide palatable food at trade shows ... the company may be more missed than it knows.



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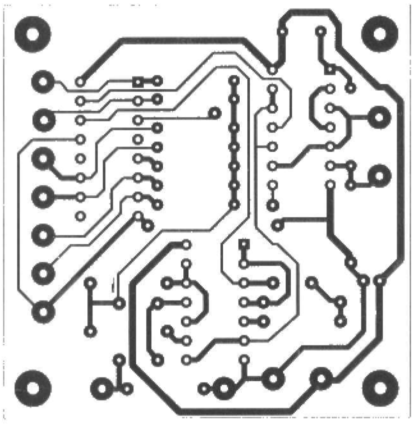

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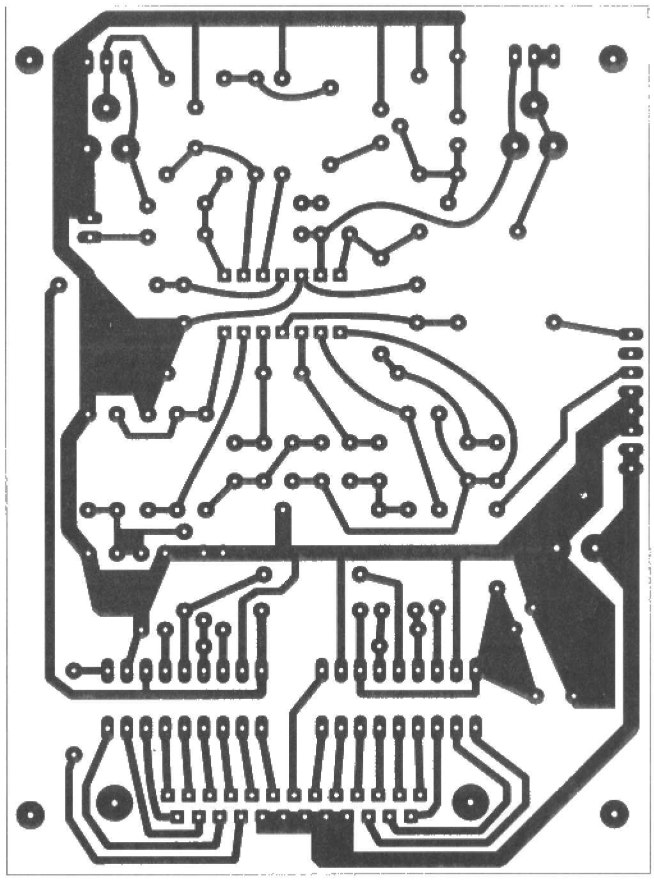

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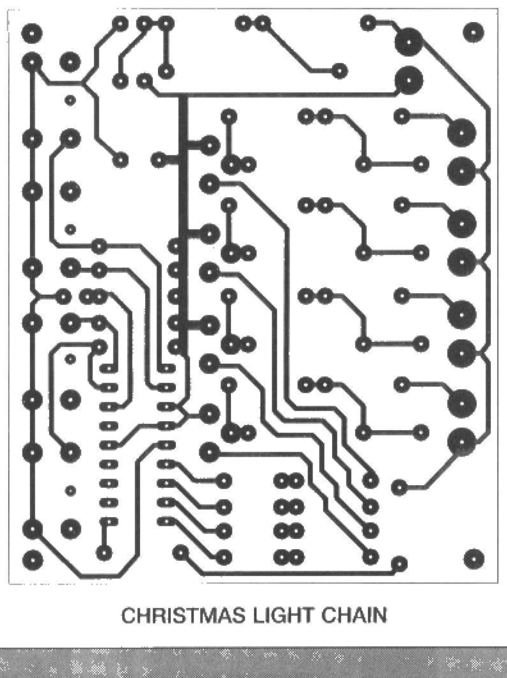
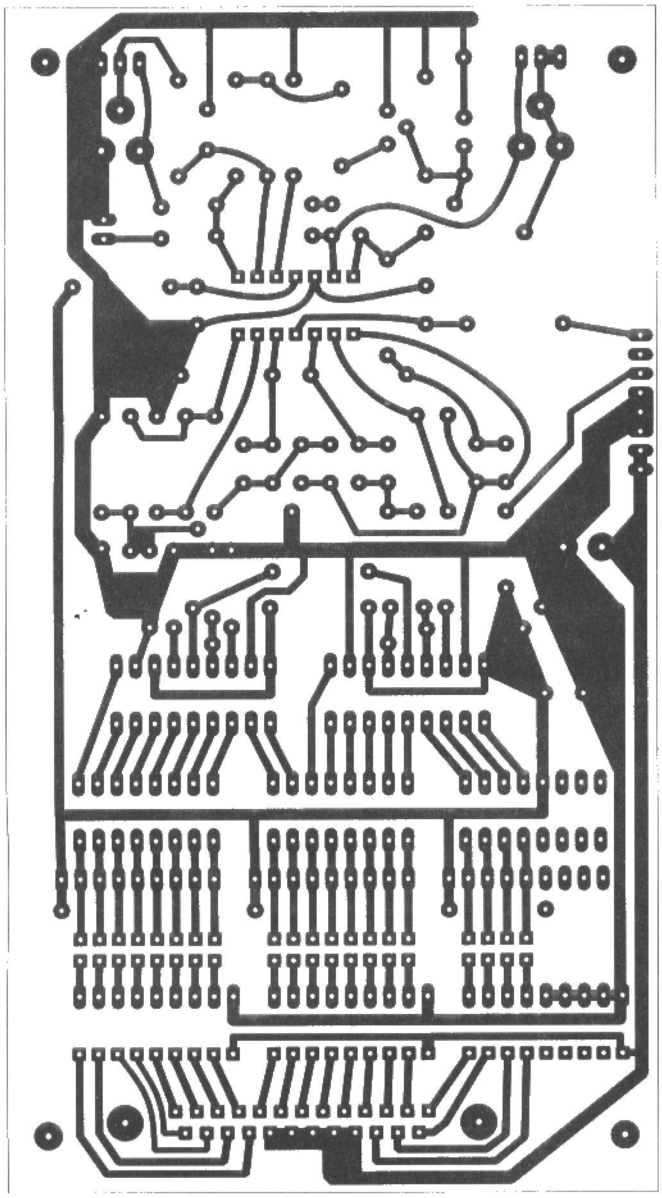


CHRISTMAS LIGHT CHAIN



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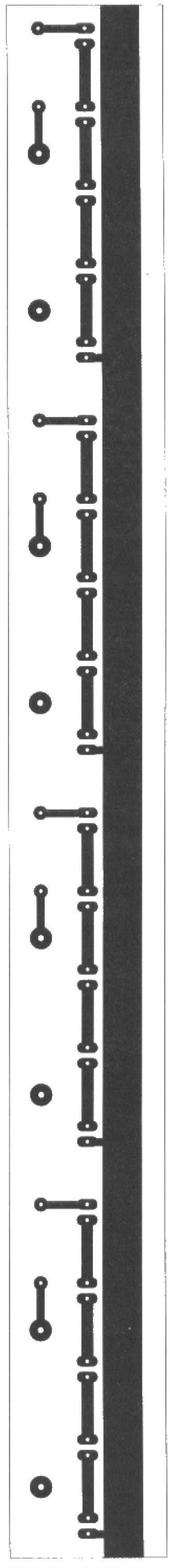
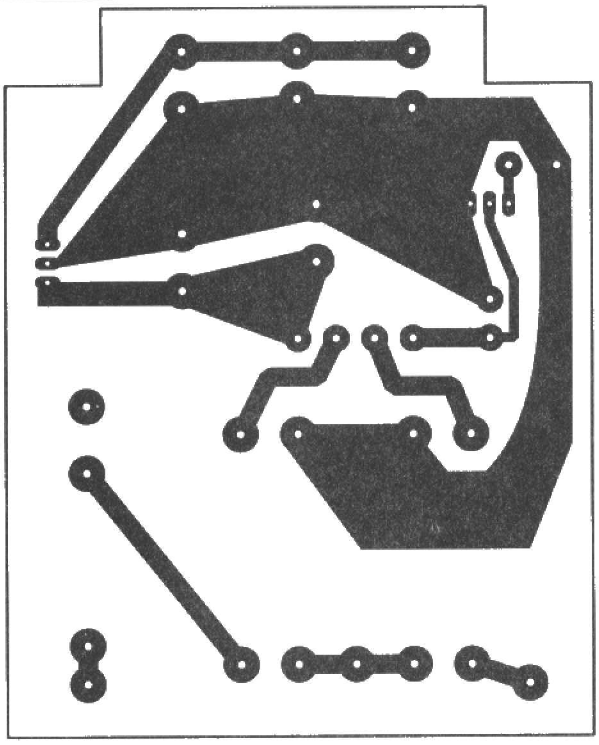
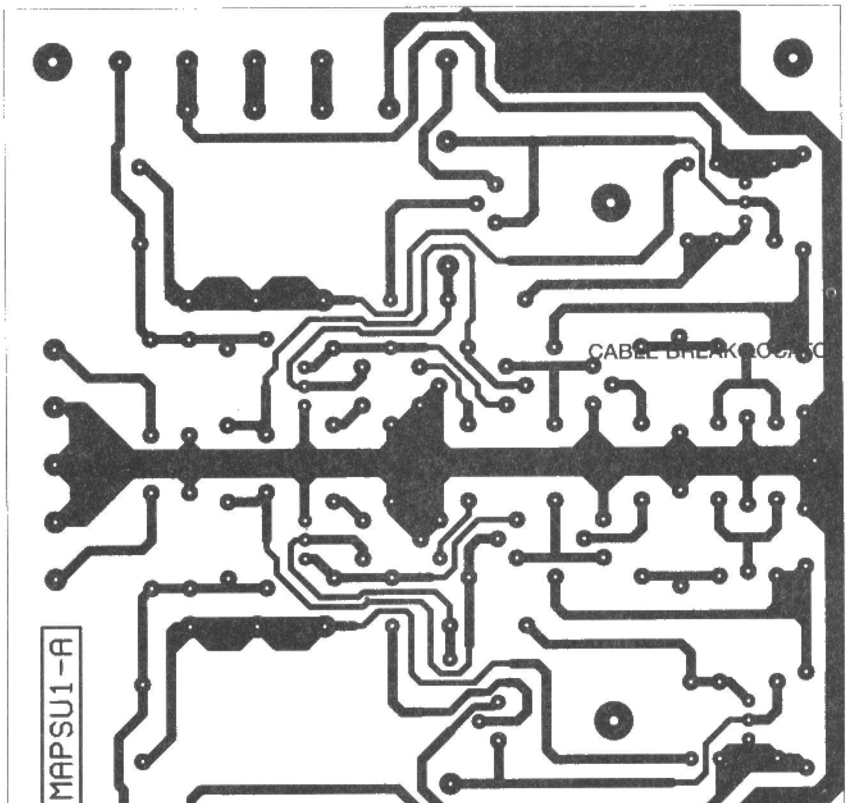
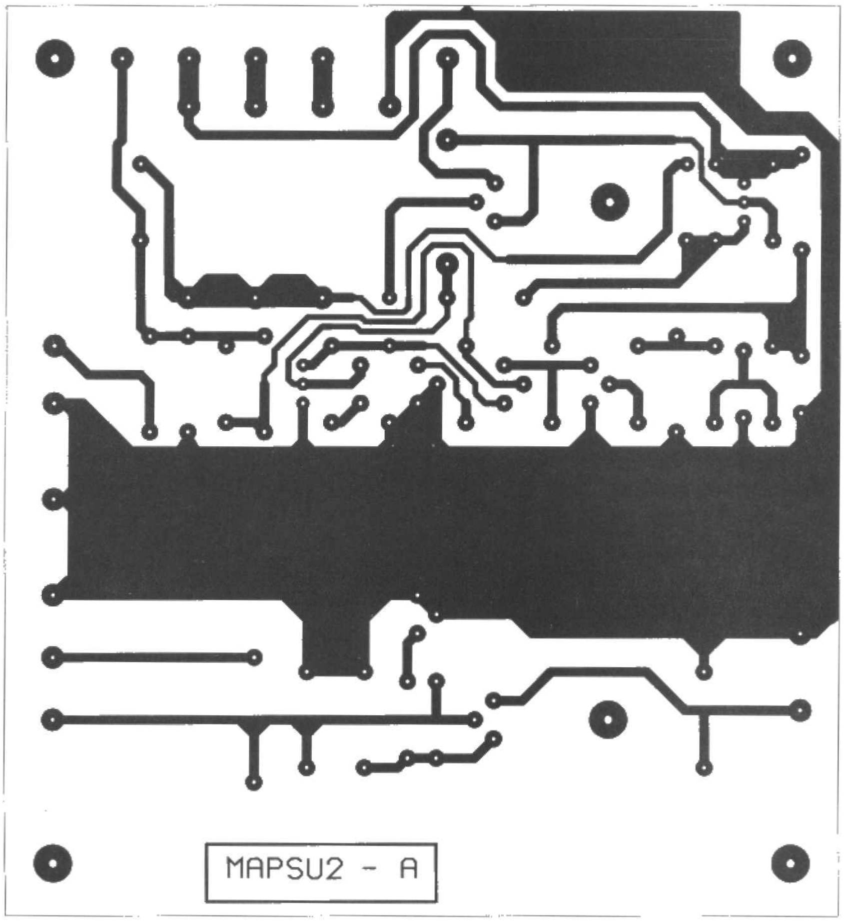




CABLE BREAK LOCATOR



ETI MICROAMP (PART 3)



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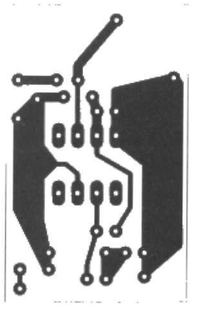
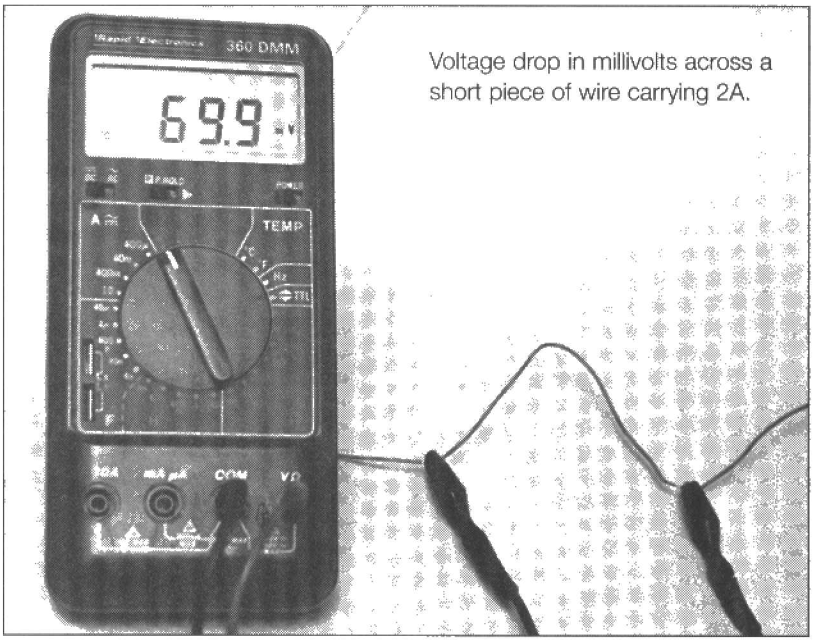


RUDOLPH'S NOSE

Practically Speaking

BY TERRY BALBIRNIE

When connecting wire is too thin for the purpose, overheating and fire may result. Wire having the correct current rating for the job must always be used. Even so, a thicker wire is often chosen simply to reduce the voltage drop and this month we shall look at this topic.



Voltage drop in millivolts across a short piece of wire carrying 2A.

When current flows through a piece of wire, a certain voltage will be developed between its ends. This is because the wire behaves as a resistor even though its value is likely to be very small. The value of this voltage drop is dependent on the current and resistance. Where the wire is quite thick and short, the resistance will be very low and if a small current flows, the voltage drop will be negligible. The photograph shows the voltage drop (in millivolts) across a short piece of wire of adequate current rating carrying 2A. A large voltage drop is undesirable because the voltage developed across the wire results in there being less for the appliance. It therefore implies a loss of useful power.

Voltage drop is more likely to be a problem in a high-current low-voltage system. As a practical example, suppose we are connecting a pair of spotlights to the 12V car system. If the bulb in each lamp is rated at 100W, then the supply wire should be capable of carrying the current for 200W of power. The current is found by dividing 200 (the power in watts) by the 12 (the voltage of the supply) and this works out at about 17A. To carry this current without overheating, copper wire having a cross sectional area of 1.5mm square would be adequate. In practice, it may be found that over a long run of such wire, the voltage drop would be too high resulting in bulbs which are slightly dimmed. The solution is to use wire which, on the face of it, seems to be excessively thick - say, 2.5mm square.

Made to measure

It is practically impossible to calculate the exact voltage drop which may be expected in a circuit such as this. The reason is that some of the effects are difficult to quantify. For example, the current in the wire will raise its temperature and thereby increase its resistance. At the same time, the current in the bulb reduces, the filament becomes cooler and its resistance falls. In practice, the eventual current would need to be measured.

In such a situation, it would be best to wire up the lights temporarily, using the correct length of the proposed wire. The voltage developed across the bulbs could then be measured. This may then be compared with the voltage at the supply. You could then make a subjective judgement - if the voltage difference exceeded, say, 0.5V thicker wire should be used. Using a digital multitester having a millivolt range, the voltage drop across a run of wire could be measured directly.

Modern in-car audio equipment can draw a very high current from the supply. To avoid an excessive voltage drop (and hence a reduction in available power) very thick wire is usually used. A typical choice is 700/0.12 (700 strands each having a diameter of 0.12 mm) and having a cross section area of about 8 mm square or even 1050/0.16 having an area of some 21 mm square!

Sounds good

A similar problem arises when operating loudspeakers at high power levels. The current delivered by the amplifier can be very high on low frequency peaks. To reduce voltage drop, and hence a degradation of sound quality, it is always a good idea to keep the wiring short. For long runs, thick wire should be used. The type known as 100/0.1 ("loudspeaker wire") and having a cross-sectional area of some 0.78mm square is often used. Over long distances, a thicker wire would be needed.

In high-voltage circuits, the current flowing for a given power is much less. For example, suppose 200W of lighting is being connected to the 230V mains. Using the same calculation as that used for the car spotlights, the current flowing is now 200 (the power in watts) divided by 230 (the voltage of the supply) - 0.87A approximately. Since the current is much lower than in a comparable low-voltage system, voltage drop will be less of a problem.

The popular type of flexible mains wire having a cross-section area of 1mm square will carry about 10A without excessive heating. When it is carrying its maximum current, and taking the heating effect into account, it will develop a voltage drop of some 0.5V per metre. If a length of 4m was used, the drop would be therefore 2V approximately. However, a "loss" of 2V in 230V would have a negligible effect.

Around the Corner

"New and unique ideas can come from many sources" is the statement under the Young Electronic Designer Awards heading of "Originality", and nothing could be truer. Technology has long been seen as the way forward to helping everyone to live longer, more rewarding, more productive lives, and though we have made great strides forward in the twentieth century, there is no shortage of goals left to achieve. Indeed, the more we do, the more it seems that we can do and need to do.

This begs the question: what is it most important to achieve? What do we need to do most? By "progress", do we mean bigger, faster, smaller, cheaper ... where is the best way forward? But there are so many things that could be done that it needs many eyes and brains and hands to choose what to do next, and (here comes the tricky bit) work out how to do it. Not everyone will have the same priorities, as people and societies have different needs. But the more interested parties put their opinions and talents into the fray, the more will be achieved in the end.

So the "many sources" really means "many people" - not just engineers, but all their prospective customers and their customers' customers - it's their wants and needs that the engineers of the future will ultimately be working to meet. In theory, everyone you meet will have some idea about how life could be improved with the help of technology, and that means, somewhere along the line, engineering.

So, if you are a designer, or a prospective designer, it's vitally important to talk to people about what you do and what they think about it. Not all of them will say, of course, "well, I think you should do so-and-so" - a lot of them will, of course, and then if you want "new and unique ideas", you are bound to hear ideas that will astound you ... if not necessarily to build them ... but if you hear between the lines you may find one of those new and unique ideas coming to mind. And it may be one you can think about building one day.

Some people will tell you that the idea's the difficult bit, and if you are looking for something to build quickly and easily and sell by the million to make a fabulous profit - the idea is certainly the difficult bit. But if you are going to follow the classic path of designing a useful project, and then obtaining the finance to making it works, getting it to market and supporting it while you build up a customer base, then it will usually emerge that these are the difficult bits, too.

Perhaps the hardest bit is "winning at engineering" versus "winning at marketing". Quite often the most advanced and exacting product design in a new field is not the eventual winner in the market - remember Video 2000, Betamax and VHS - when they first emerged, the former two systems were in some ways more advanced than VHS, but the makers of VHS moved quickly to get video movies out in their format, so supplying the market and getting the customers' support. Of course, if VHS had not been a workable system in its own right - and been steadily developed since - it would not have held its customers' loyalty - but it demonstrates how product developers must have their eyes and ears pointing in many different directions at once.

This is the outlook that industry-sponsored awards like the Young Electronic Designer Awards are putting their efforts into promoting, along with all the aspects that go with good practical design - reliability, a practical attitude to manufacturing, realistic costing, meeting a genuine need at the right time (many good ideas have come to market too early or too late to catch their natural customers), and awareness of how user-friendly the product will prove to be in use.

I personally look forward to the day when my car goes into conference with my fridge and my cooker to present me with my supper as soon as I get home - as long as I have some say in the matter, of course.

The Challenge - *Things that electronics hasn't fixed yet*

We have lie detectors. Some of them are felt to be reasonably reliable, but none of them are unbeatable.

Suppose we had a machine that could tell reliably whether the subject really believed in what he or she was saying? Or - even more drastic - really believed in what they thought they believed in? Would it change the relationship of mankind to machines and, indeed, mankind to mankind? Especially round the Christmas dinner table ..

Send your suggestions to the Editor at the address on the right.

Next Month

Volume 26, no. 1 of Electronics Today International, arriving at your newsagent in early January, will bring a very sane simple low-cost Digital Frequency Meter from the "MadLab" ... from Robin Abbot, the first in a three-part series on experimenting with video signals, along with a sync separator module to build ... Richard Grodzik presents a PIC16C54-controlled, portable Remote Data Logger that can upload to a PC ... we shall be hearing the latest wisdom on Smart Cards from Nick Hampshire ... Terry Balbirnie has some ideas in his heart for St. Valentine's Day ... and more ...

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